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MINERAL RESOURCES OF CANADA

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ON THE ORES OF

COPPER

IN THE PROVINCES OF NOVA SCOTIA, NEW BRUNSWICK AND QUEBEC.

BY

R. W. ELLS, LL.D., F.R.S.C.

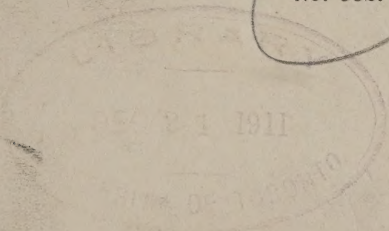


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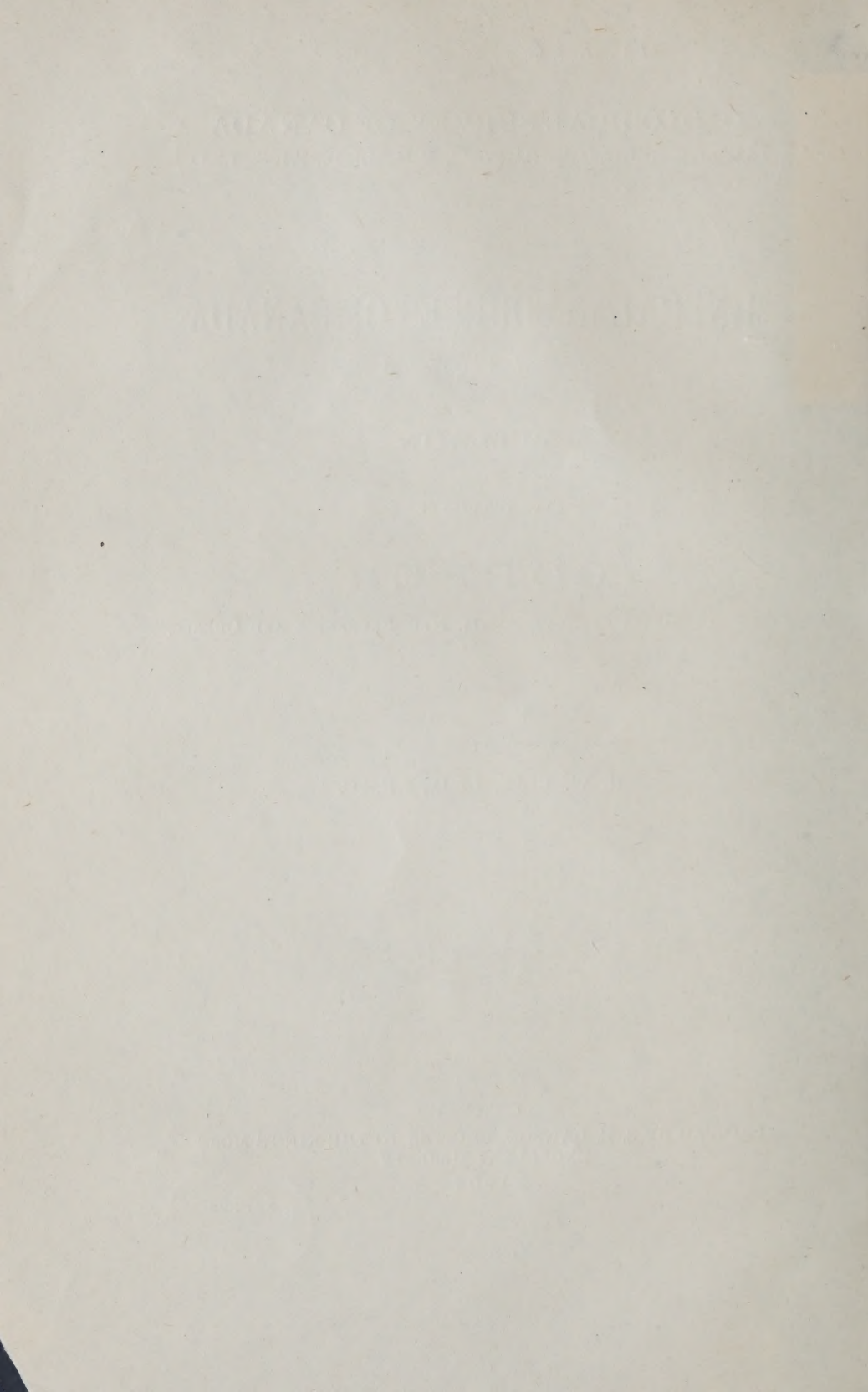
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ON THE ORES OF

COPPER

IN NOVA SCOTIA, NEW BRUNSWICK AND QUEBEC.

By R. W. ELLS.

The presence of copper has been ascertained in nearly all parts of the Dominion of Canada, with the exception of what is known as the prairie section and in the great Lower Laurentian areas on either side of Hudson bay. In the far east its occurrence around the shores of the Bay of Fundy was recognized nearly 300 years ago by the early French explorers in 1608, and mining has been carried on at intervals in the adjacent province of New Brunswick for more than half a century. The copper deposits of Quebec are in many places large and important and have been mined for the same length of time. Those of Ontario have long been exploited, in some cases with a fair amount of success, while in the western portion of the Dominion copper mining has been carried on with varying success for some years. In the far north the copper of the Barren Lands was reported by Arctic explorers nearly a century ago, but owing to the great difficulties connected with exploration, the real importance of these deposits, as on the Coppermine river and in the rocks of the west side of Hudson bay, has never been fully ascertained. Early references.

In the treatment of this subject it is proposed to discuss the distribution of these ores by provinces, beginning on the east or Atlantic portion of the Dominion, and to consider first of all the known occurrences in the province of Nova Scotia.

A review of the literature pertaining to the copper deposits of eastern Canada, more particularly as relates to this province and to those of New Brunswick, where the occurrences present many similar features, reveals the fact that, although the presence of ores of various kinds has been known and referred to in many publications for nearly a century, and large amounts of capital have been expended in developing what appear to be promising localities, but little of economic value in the way of direct profits, has as yet resulted.

NOVA SCOTIA.

Copper ores
of Nova
Scotia.

In this province, though the presence of native copper was observed in the igneous rocks of the Bay of Fundy by Lescarbot shortly after the arrival of the early French explorers in that country, in the development of that province but little attention was directed to the nature of such deposits for more than two centuries. At a later date, 1828-29, the presence of this mineral was fully noticed by Messrs. Jackson and Alger who made a somewhat extended examination of the igneous rocks along the Bay of Fundy, and in his report, 1836, Dr. Gesner called attention to the presence of ores of various kinds in different parts of the province. Numerous references were also made to the presence of these ores by later writers, including Professors How and Hind, Messrs. Poole, Gilpin and others, in papers to different scientific societies and in reports to the provincial government. Since the advent of the Geological Survey, in the eastern provinces, subsequent to the period of Confederation, careful attention has been given to the occurrence of all minerals of economic value, and the localities where such minerals have been observed have been pointed out. Descriptions of many of these may be found in the several reports by Mr. Hugh Fletcher for nearly thirty years. From a study of the available information relating to this subject the following synopsis is presented. Certain information as to details of mining and economic results are of necessity omitted, since as regards the working of many of these deposits during the last forty or fifty years there is very little information of value to the general public to be obtained.

The copper ores of the province present considerable variety and occur under widely different geological conditions. In the broad sense they may be classed under four general heads.

Mode of
occurrence.

1. Those pertaining to crystalline rocks, mostly felsitic in character, and occurring at a number of points in the eastern part of the province, especially in the Island of Cape Breton.

2. Those found partly in connection with intrusive rocks which cut Devonian and Silurian strata of the eastern part of the province; and as contact deposits in these formations.

3. Those which occur in rocks of Carboniferous age, more especially in the upper Carboniferous or Permian beds in the area south of Northumberland strait. These ores evidently owe their presence to the action of organic matter in the form of plant remains upon copper in solution.

4. Those which are found in connection with the great trappean outflow of the North Mountain range and in similar rocks on the north side of the Bay of Fundy, from Five islands westward to Cape d'Or. In this case the copper is principally in the pure or native state, sometimes becoming green on the surface through oxydation.

THE ORES OF THE FIRST DIVISION.

The ores found in connection with the felsitic rocks of Cape Breton and elsewhere are usually in the form of copper pyrite associated with iron pyrite and sometime with galena and zinc blende. At some localities gold has also been found in small quantities. Most of the occurrences in this district, in so far as described by Mr. Hugh Fletcher, in his reports to this Department, are undoubtedly small in extent and give but little promise of successful returns from their development. In some localities, notably at Coxheath and at Cheticamp, certain conditions have occurred which have produced a greater development of these ores, and at the former a large amount of capital has been spent in mining plants, for which as yet but small returns have apparently been realized. At Cheticamp the ores are found associated with schists, generally felsitic, and there is a greater diversity in their character, some of the ore-bodies being of large extent. Usually however the copper pyrite is found along joints or fissures in the shattered felsite rock which is generally reddish or grayish in colour, resembling much of that found in southern New Brunswick and in parts of the felsite belt in the northern area of that province. In geological position, they have been referred to the pre-Cambrian series. Sometimes the ore occurs in irregular quartz layers which traverse the felsites.

Ores of the first division.

Among localities where these ores have been found in the Cape Breton district in varying amount may be mentioned the following, taken from Mr. Fletcher's reports.

Caribou Marsh road, two miles from Gabarus bay. Copper pyrite in compact felsite, nowhere apparently in paying quantity. Eagle head, Gabarus bay; deposits of rich ore in the form of pyrite and mined to some extent about 30 years ago. The felsite contains quartz layers, one band reported to have a breadth of four feet which was worked in the old shaft, but the prospect of finding a valuable deposit does not seem greatly improved. Associated with the feldspar and quartz, a band of whitish green soapstone was found in shaly layers by Mr. Angus Campbell of Sidney, with arsenical pyrites, bismuth-glance, iron pyrites, molybdenite and traces of gold. Report Geol. Sur. 1877-78, p. 29 F. The shaft is reported to be sunk to a depth of 75 feet.

Gabarus bay.

In Gilpin's report on Mines in Nova Scotia, 1880, the belt of laminated quartz is said 'to have a thickness of 25 feet, intermixed with soft felspathic rock. The quartz layers are of varying thicknesses and carry the ore in irregular quantities. Shafts have been sunk at the Eagle Head and French Road deposits by Mr. F. Ellershausen, and it is understood that well-defined and promising veins have been found. Work has been abandoned for some years.

Boulaceet
harbour.

In the section between Burnt point and Boulaceet harbour, copper pyrite in small quantity is found in veins cutting a grey micaceous laminated quartzite of the crystalline series; and at the silver mine on this harbour a rich pocket of galena, with copper and iron pyrite holding some silver and gold, was found in a small vein of $\frac{1}{2}$ to 4 inches thick and mined to some extent by Mr. A. Cameron of Baddeck. Report Geol. Surv. 1876-77, p. 407.

Washaback.

Similar occurrences are recorded from the Washaback district, the copper and iron pyrite being in irregular quartz veins with blende and galena. In a conglomerate at Washaback near Crow point copper ores are found, probably induced through the agency of plant stems on the metal in solution, which have given by assay appreciable quantities of gold and silver. Gilpin, 1880, page 80.

In the felsite of Blue mountains small quantities of copper occur, as also in the White Granite hills near French river. The ore is in the form of pyrites with iron pyrite, but the amount appears to be of small economic importance.

At Three Island cove, copper and iron pyrite are found as mere specks only, in quartz veins crossing black and gray slate and sandstone and the deposits are of no apparent value.

Various
localities in
Cape Breton.

At Grantmire brook, iron and copper pyrite are found in layers in a compact gray and pink felsite, the ores yellow and purple, weathering into the green carbonate.

In a brook just west of Morrison road near West bay, traces of green carbonate of copper were found in a quartz-felspar rock, associated with soft soapy calcareous rocks like those at Coxheath and Gabarus.

At North-east harbour and Skye mountain, copper pyrite in small veins cutting felsite rocks, mined to a small extent.

Gillis Lake road, yellow and purple copper pyrite, scattered through a large mass of compact and brecciated felsite; in places calcareous and full of a soft soapy talcose material. Some mining was done at this place by Mr. Burchill.

Brooks near the Coxheath road at Battleman's above the mineral spring, traces of copper ore.

Green island ; specks of iron and copper pyrite in small quartz veins cutting dark gray felsite ; of no economic value.

Shore east of Big harbour ; veins of copper ore traversing diorite, schist and gneiss ; have been worked to some extent.

Stewarts brook ; small specks of copper pyrite in veins and beds of limestone, with schist, felsite, quartzite and diorite.

Jerome brook ; copper pyrite in quartz-veined syenite and compact red felsite with diorite. Mined to some extent.

On mainland, west side of Great Bras D'Or lake, opposite Man of War point, copper pyrite in a compact bluish-gray gangue ; the ore by analysis gave, copper 14.28 per cent.

Coxheath mountain ; probably the largest of these deposits at present known in this district. Opened first about twenty years ago and worked at intervals since that time. A large amount of capital expended in development works and mining plant. The ores are copper and iron pyrite in bodies sometimes of large extent, occurring in felsite which is often much fissured and broken ; the ores carry small amounts of gold and silver. In the deposit there is a small quantity also of calcite and quartz. The first work was done in 1880, and four shafts have been sunk to depths of 300, 420, 100 and 45 feet. Numerous trenches and trial pits have also been made, in order to prove the extent of the deposit. The last shaft was sunk in 1892. Work has been suspended for several years. When examined by H. P. Brumell in 1892 he reported the cupriferous belt as 1,500 feet thick in which ore-bodies occurred in veins from two to twenty feet wide. The underground workings consist of tunnels and drifts. A large quantity of ore estimated at from 2,000 to 3,000 tons has been extracted, portions of which have been hand-picked and partly crushed and jigged, but apparently no shipments of the ore have been made with the exception of small amounts for sampling. The quantity of copper in the ore is given in the last report of the Nova Scotia Department of Mines as seven per cent, from a sample taken across the ore pile. The expenditure of money in the development has been very large, but the area has not yet been placed on a paying basis.

George River mountain ; R. A. L. Watson's area, chalcopyrite, some of high values.

George River mountain, Alex. Matheson area, chalcopyrite.

French road, Cape Breton Co.; J. A. Mackenzie & Co., chalcopyrite.

Cheticamp
mines.

Cheticamp. The copper at this place was referred to by Mr. Fletcher in several of the early reports on this district as far back as 1882. He says of the locality (Report, 1882-84, p. 95 H.) 'For some years prior to 1865 a company was engaged mining for copper ore at Cheticamp, and in 1864, about 12 men were employed. A shaft was sunk to a depth of 106 feet and connected with an adit 410 feet in length. An air shaft 30 feet in height was also cut from the adit-level to the surface of the ground, but not proving productive the works were discontinued. They are situated in the vicinity of the trap and sandstones at the base of the Carboniferous. Professor How mentions that green and blue carbonate of copper, gray and yellow copper ore in calcite and chrysocolla are found at Cheticamp, probably at this mine or at Jerome brook, as well as perfect crystals eight inches long of red feldspar in the pre-Cambrian syenite of the neighbourhood.'

Quite recently the property has been taken up by the Eastern National Copper Co. which has begun development work at Grandin brook. L'Abime river. The ore which is chiefly chalcopyrite occurs in schists, and the ore-bearing zone is said to have a breadth of 70 to 100 feet, but the present operations are confined to a thickness of 10 feet. The ore is reported to be mixed with galena and other minerals, and to show a small percentage of gold and silver. The copper contents run from $2\frac{1}{2}$ to 5 per cent, with an average of 3 per cent. At present the work on the property is only in the development stage.

Adjoining this area is another known as the Richfield Mining Co. which is developing another ore-body of presumably similar character. Along this shore of the island similar pyritic deposits are found in small quantity at several points north of Cheticamp, as at Poulet cove, near Money point and at Cape North. These are practically all copper pyrites in felsitic rocks.

From the evidence as yet presented regarding these pyritic areas, it would seem that the occurrences at most of the localities mentioned are too limited in extent to be of much economic importance. The largest ore bodies appear to be at Coxheath and near Cheticamp.

ORES OF THE SECOND DIVISION.

Ores of the
second
division.

The copper ores of the second division are for the most part contact deposits occurring near intrusive masses of diorite or other igneous rocks and pertain to sedimentary formations including Silurian, Devonian or Lower Carboniferous strata, at the contact of the limestone and underlying conglomerate.

Of the latter, Fletcher mentions the occurrence of copper-glance, oxydized to carbonate, at Irish cove, Washaback, Middle and North rivers, Cape Breton. The ore occurs often as impregnations in the conglomerate at the contact of the limestone. An analysis by Hind shows a small percentage of gold in this ore.

The Polson Lake deposits and those of Lochaber, about four miles distant, Antigonish county, appear to come under this class. This area is well described by Fletcher (Report, 1886, pp. 119-120.) The ores apparently occur in Devonian slates, in a series of veins associated with spathic iron ore, which cut red and black slates and quartzite and are broken across by diorite dykes. In Gilpin's report, 1880, it is stated that six of these veins have been located and partly opened up, varying in width from $1\frac{1}{2}$ to 6 feet, carrying copper pyrite with erubescite and carbonate. The copper contents vary and by assay amount in places to 31.25 per cent of metallic copper. The properties have been developed to some extent, but no mining has been done in the area for some years. It is probable that a close relation exists between the ore bodies and the intrusive dykes of the district. At the Lochaber mine a whitish granular diorite or granite is found, which, as at Polson lake, breaks through the purple slates. Polson Lake mines.

Some of the occurrences at Cheticamp are also apparently of this nature where the ore is found at the base of the Carboniferous near the trap dykes; and at Jerome brook the ore is sometimes associated with a dioritic mass, and in places changed to the green carbonate at the surface. The vein at this place sometimes has a thickness of a foot or more, but is irregular and the deposit is not persistent. Mines in Cape Breton.

On the Great Bras D'Or lake, in the brook east of Big harbour, (Point Bevis) quartz veins in diorite carry small amount of copper with galena; and on the shore of Ste. Anne harbour there are small irregular veins of calcite and quartz, holding copper pyrite, hæmatite and galena, which were tested some years ago by Col. Bingham and others.

Traces of copper ore are also found on McLean and Stewart brooks, and in Big Intervale of Margaree, but so far as known are of no economic value. In the Stewart brook the rocks are felsites, hornblende and mica schist cut by diorites, with beds of crystalline limestone. Mines in Eastern Nova Scotia.

At Pomquet forks, in a series of gray flags, slates and marly shales, in which plant remains are sometimes found, the stems are occasionally converted into coal and sometimes into green carbonate of copper and gray sulphide. This occurrence is similar to those observed in the

Various
localities.

Upper Carboniferous or Permian rocks of Colchester and Pictou counties.

At Knoydart brook, gray and green flaggy sandstones with plant stems, present similar deposits at several points.

On Brierly brook, deposits of copper are found near the contact of green conglomerate and limestones of Lower Carboniferous age, and have been mined to a limited extent.

At Ballentyne cove the green carbonate is seen in a similar conglomerate, overlaid by a light gray limestone. The ore, found mostly at the contact, is yellow and purple copper pyrite, seen at a number of points and has been worked at intervals for some years. Near the upper end of the Ohio river a mass of brecciated felsite occurs beneath the Lower Carboniferous limestone with deposits of copper pyrite, blende and galena. The rocks are greatly broken up, and according to Gilpin the ores carry small amounts of gold and silver.

On the Arisaig shore at the pier, there are small irregular veins carrying copper and iron pyrite with some galena, as also at a point in rear of the chapel at this place. On the Mill brook, crossing the St. Mary road above Eden lake, a small irregular vein of calcite is seen which carries small specks of copper pyrite.

On McAllister brook near Guysborough, specks of copper pyrite are seen in a greenish or black brecciated rock, filled with threads of quartz.

From the descriptions of these areas it would seem that most of them are of little economic value, and that the largest are those found in the Lochaber and Polson Lake district. These have been worked at intervals for some years but apparently without much success.

Other occurrences are found in the vicinity of McLellan mountain, as small pockety crystals of copper pyrite near the contact of Cambro-Silurian slates and igneous rocks. At Rocklin mills traces of ore are seen in Devonian slates; in minute quartz veins on the West branch of Middle river; in a brook near Pembroke, and elsewhere, all being associated with Devonian slates but of no apparent value.

THE UPPER CARBONIFEROUS DEPOSITS OF THE STRAIT SHORE.

Ores of
northern
Pictou,
Colchester
and Cumber-
land Cos.

The presence of ores of copper, including gray sulphurets and carbonates in the gray and red shales and sandstones of the Upper Carboniferous, or as it is sometimes called the Permian formation, which

is extensively developed in portions of Pictou, Colchester and Cumberland counties, has long been known. They have been referred to in the reports by Jackson and Alger as far back as 1828, by Gesner and Dawson, and later by the officers of the Geological Survey. The associated rocks extend for many miles along the south side of Northumberland strait which divides Nova Scotia from Prince Edward island, where a similar geological formation occurs in which also at several points traces of the same ores are recognized.

Attempts have been made for half a century to mine these ores, but without much success. Within the last dozen years these operations have assumed larger proportions by the establishment of well organized companies and the erection of a more systematic mining plant, so that a large amount of capital is now invested in this direction in the attempt to put the extraction of these deposits on a paying basis.

The ores are mostly in the form of vitreous or gray sulphurets and green carbonates, and are often associated with jetlike coaly matter or lignite which is evidently due to the alteration of plant remains, the mineral being apparently deposited through the agency of the organic matter of the plants upon copper in solution. The deposits are found over a very wide area of these rocks and at a great number of points both in Nova Scotia and in New Brunswick where also attempts to mine similar ores have been carried on for some years.

Copper deposited through organic agencies.

Among localities in Nova Scotia where these ores are found may be mentioned the following, taken from the Reports of the Geological Survey and the Department of Mines, N.S.

East river of Pictou near Hopewell; West river near Durham; French river; Waugh river; Caribou river about eight miles north of Pictou; Wallace river at several points; Tatamagouche; Pugwash; Chisholm brook and Canfield creek, Pugwash river; Athol; Oxford; River John; Salmon river; Malagash point; Doherty creek; River Philip; Fox harbour; Gulf Shore; New Annan; Wentworth; Henderson settlement; Nappan and Maccan. The above list shows the widespread nature of the conditions under which these ores have been deposited. Probably a closer search will disclose similar occurrences at other points.

Localities.

These ores are usually found in beds of argillaceous sandstone and conglomerate, and sometimes in the associated red and gray shales. They occur as nodules and irregular seams or layers of the gray ore, deposited upon carbonized plant stems. The percentage of copper is high, amounting at times to seventy per cent of the metal. The

scattered nature of the deposits has however, so far been very much against their economic exploitation, both in this province and in New Brunswick.

Considerable sums of money have been spent in mining these ores on the French, the Wallace and Waugh rivers, as well as elsewhere, but the actual returns have never been published.

As an illustration of the mode of occurrence of these deposits the statements given in Gilpin's report, Department of Mines, Nova Scotia, 1880, relating to the French river deposits above Tatamagouche may be here quoted.

French
River ores.

'On the west side the gray sandstone beds near the top of the bank, carry the nodules disseminated through them to a depth of about 4 feet, the principal deposit being in a dark gray bed from 8 to 10 inches thick. Owing to the action of subaerial agents, the bed has a greenish cast, and the nodules are coated with carbonate. The nodules are on an average small, not larger than cherries, though some have been found weighing one pound and a half. When I visited this locality the drifts had so fallen in that it was impossible to estimate the apparent extent of the deposit, but from what was to be seen, it appeared not improbable that the nodules were not equally disseminated throughout the bed in which they were found, but are collected together, as at eddies or banks in the sandstone deposit. Below the gray beds, come beds of a reddish colour, and below them, close to the river's edge, other gray beds in which are the remains of plants, the tissue of which has become filled with copper pyrites.'

As an illustration of the amount of ore that can be obtained from these deposits it may be quoted from the same report as follows:—

'1876-77, the work of twelve men produced, according to statement of Mr. Prendergast, the manager, some 36 casks of ore, each averaging about 900 lbs. Subsequent work for two months yielded 6 more casks, averaging 800 lbs. each, or a total of $18\frac{1}{2}$ tons, valued in New York at \$120 per ton. The excavations made extended along the bank about 400 feet, and inland for over 200 feet; in length they measured nearly 2,000 feet.'

While operations have been carried on in this area at a number of places within recent years there appears to be no means available by which actual estimates of profit or loss from such work can be made.

From the last report of the Department of Mines, Nova Scotia 1904, the following data are given as to companies now or recently operating in this district.

Chalcocite and malachite. Hon. S. H. Holmes lease, Caribou river, Caribou river. Pictou Co. Deposit known for a considerable time and a fair amount of prospecting has been done. Some ore extracted by the Copper Crown Co.

Chalcocite nodules. Colonial Copper Co's mine, French river, 4 miles south of Tatamagouche; worked at intervals for 60 years by different parties. Now owned by the Colonial Copper Co. The property has been well prospected, and a number of tunnels, shafts and boreholes have been driven and put down. At present idle.

Chalcocite and malachite with lignite in sandstone. W. A. Mc. Pugwash area. McPherson's mine, John Chisholm brook, Pugwash river, Cumberland Co. Prospected by Messrs Chisholm and McPherson. Four trial pits and a tunnel are on the property. The copper-impregnated sandstone beds are supposed to have a thickness of 12 feet and are said to have been proved on the strike for over 100 feet. Four or five tons of chalcocite were shipped to Boston and some tons are now on the site.

Chalcocite, and malachite, in sandstone. W. A. McPherson's claim Canfield creek. This deposit, prospected by Mr. McPherson in 1902; sank shaft 25 feet and a quantity of ore was taken out.

Chalcocite, malachite, &c. in sandstone. Amos Blenkhorn mine, Acadia Copper Co. between Nappan and Maccan, Cumberland Co. ^{Maccan and Nappan.} Copper found here about ten years ago. Five years ago, a good deal of prospecting done and a timbered slope about 80 feet long, dipping southward about 47 degrees, was sunk and a few tons of picked ore shipped to the Copper Crown smelter at Pictou. Ore reported to assay from 5 to 46 per cent metallic copper. Associated with it are argentiferous galenite, azurite, sulphides of iron and copper, also lignite; gold is said to have been present in some of the assays. Property now unworked.

Other occurrences of these ores are taken from several reports. They include the shore between Cape John and Toney river; at Dewar river, Scotchburn brook; River John and Plainfield brook near the forks; and at other points in the vicinity. These occurrences are all similar to those just described.

COPPER IN THE TRAP ROCKS OF THE NORTH MOUNTAIN RANGE.

The copper of this range of rocks which include several outliers on the north side of Minas basin and the Bay of Fundy, has been referred to in several early reports. It was noticed by Lescarbot, 1608, by ^{Ores in the Trap formation.}

Jackson and Alger, Gesner, and others. The observations of these early writers apply more particularly to the locality known as Cap d'Or on the north side of the bay, where scales, grains and small irregular veins of native copper are seen in certain bands of the trap formation, and from the bright yellowish-red colour of the mineral, these apparently led to the inference that gold was present and thus gave the name to the locality.

Character
of rock.

The trap rocks of this district consist of several kinds, including heavy layers of the columnar variety, some of the columns being curved and others upright, sometimes forming a perfect floor along portions of the beaches. These are often overlaid by massive traps, and sometimes by beds of trap ash, often highly amygdaloidal and holding a fine variety of zeolites in great perfection as regards their crystallization, so that this part of the province has long been a favourite area for mineral collectors.

Cap D'Or
mine.

At Cap d'Or the native copper can be readily seen in certain beds exposed in the coast section at the end of the point and along the east shore in the direction of Spencers island. The containing rock is often a reddish-brown trap-ash through which the metal is disseminated, both as minute grains and in small pieces like fish-scales, as well as in small and irregular veins. Occasionally pieces of several pounds weight are obtained. An attempt to mine these ore-bodies was made by a Halifax company about thirty years ago, near Horse-shoe cove two miles north-east of the end of the cape, but the place was soon abandoned.

The height of the cliff is about 350 feet, and several copper-bearing zones are found. On the west side of the cape the columnar trap at the base is overlaid by the copper-bearing reddish, slightly porphyritic and sometimes amygdaloidal trap which sometimes has a breccia or trap conglomerate in its lowest part. There is sometimes a marked aspect of stratification in the several series which make up the face of the cliff with an apparent dip to the east on the west side, while on the east side near Spencers, the dip appears to be reversed. Zeolites are more abundant on this side than on the west part of the cape. After passing the high promontory which forms the south side of Spencers cove the red Triassic sandstones come in and extend north to the contact with the older series of the main shore.

Character of
work done.

In 1900 the Colonial Copper Co. acquired a large area at this place amounting to 2300 acres, and proceeded to erect a mining plant for the extraction of the native copper from the trap. A large amount of work has been done, involving the expenditure of several hundred

thousand dollars, in development work and machinery. A concentrating plant has also been erected. In the last report of the Department of Mines, Nova Scotia, 1904, it is stated that 'No. 1 lode shaft has a length of over 371 feet with over 1000 feet of tunnels and drifts. No. 2 lode slope going south 326 feet and another slope going north 300 feet with 800 feet of tunnels and drifts. No. 3 lode shaft, depth 180 feet with tunnels and drifts of over 300 feet. A railroad has also been built from the mines to the mill. The native copper occurs here in veins and joints in the Triassic trap.' No actual statement of cost of winning the metal is apparently obtainable.

Similar occurrences of the ore are found at a number of points in the trap area. Thus on the south side of the Bay of Fundy, a cupriforous basalt is met with at the mouth of Bishop brook, three miles east of Margaretville, which was opened to some extent by a short adit from near the water line but soon abandoned. Reference has also been made by Professor Bailey in his Report on western Nova Scotia, (Vol. IX, 1896, p. 140 M.) to the presence of copper in these rocks in Annapolis and Digby counties, and pieces of native copper of several pounds weight have been found on the beach. On the north side of Minas basin the metal is also found in small quantity at Five islands and at Cape Sharp. In all these places the quantity present does not appear to warrant the erection of a mining plant, the deposit at Cape D'Or being the most promising in the entire district.

Other occurrences on the North Mountain range.

Among other places which have been mentioned in various reports as containing ores of copper are East Dalhousie, Kings county, where quartz cuts across the granite and carries vitreous and gray sulphuret ores with carbonates. These have been opened to some extent, and assays show the presence of silver also, in small quantity.

At Blandford cove in Lunenburg county, Mr. Poole, 1862, reports the presence of copper pyrite in slates, as also at Hillsboro brook, Westfield brook, Geysers hill, and Jebogue point. It is also reported as occurring frequently in the gold-bearing lodes of the province.

NEW BRUNSWICK.

The conditions relating to the occurrence of copper in this province, are somewhat similar to those already described for Nova Scotia. The principal known deposits, may be classed under four heads, viz :

1. Those in connection with pre-Cambrian rocks, comprising schists, felsites, &c. as seen in the mines opened at several points along the north side of the Bay of Fundy, in St. John and Albert counties ;

Copper ores
in New
Brunswick.

2. Those associated with masses of eruptive rocks which cut strata of Silurian and Devonian age, as in southern Charlotte county, in Letite, Adams and Simpson islands, etc.;

Mode of
occurrence.

3. As gray copper ore thrown down by the agency of plant remains in sandstone and conglomerate of Carboniferous age, as at Bathurst in Gloucester county, and near Dorchester in Westmoreland county ;

4. In trap rocks, of supposed Triassic age, found chiefly on the west side of the Island of Grand Manan ; the igneous rocks of that area, being regarded as contemporaneous with those of the North Mountain range, in Nova Scotia.

Early reports.

Reference was made to some of these occurrences by the earliest writers on the geology of the province, including Gesner, Hind and Dr. Robb, of the University of New Brunswick, and later, by Mr. C. Robb and Messrs. Bailey and Matthew, as well as others, engaged in the work of the Geological Survey. As in Nova Scotia, large amounts of capital have been spent from time to time in the attempt to bring certain of these deposits to a state of economic production, but up to the present, these efforts have not been attended with much profit to the investors.

Gesner in his first report, 1839, on the geology of the province, notes the presence of several veins of sulphuret and copper pyrite, with a thickness of two to four inches, as occurring on the shores of Passamaquoddy bay, near the mouth of Digdequash river, the percentage of copper being high, but the extent too limited to be of economic importance. In his second report, 1840, he also refers to the work of the Gloucester Mining Association, as attempting to develop certain occurrences of copper ore in Gloucester county, and also to the presence of ores, comprising sulphurets and carbonates, which were observed along the road, between St. John and Quaco.

Ores of
Gloucester
county.

In the report of Dr. L. W. Bailey, 1863-64, on the 'Mines and Minerals of New Brunswick', the presence of copper ores is recorded at many points in the province. Among these may be mentioned the deposit at Bathurst, which occurs in the sandstone of the Bonaventure formation, in the form of carbonate, thrown down from solution by the agency of plant stems, which have in part been changed to lignite. This deposit was mined for a short time, till the plant bed was exhausted, when the locality was abandoned. This is probably the first attempt at copper mining in the province. In its mode of occurrence, the ore resembles that found in the Carboniferous of northern Nova Scotia. Attention was also directed in this report, to the presence of copper and manganese, at or near the Falls of the Tête à

Gauche river in Gloucester county, which was opened by a mining company, and a small mining and crushing plant erected for the extraction of these ores. The rocks are reddish and grayish slates, often charged with nodules of manganese, while blocks of good copper ore were scattered over the surface. The enterprise was, however, shortly afterwards abandoned.

In Charlotte county, several mines were long ago opened in the Letite peninsula, including those known as the Letite copper mine and the Wheal Louisiana. These were among the first attempts made at mining in this part of the province; and although a considerable amount of money was spent in sinking shafts and driving levels, the results obtained were such as to cause the abandonment of the enterprise. Indications of copper with galena were also seen on the west side of Campobello island, but these deposits have never warranted the expenditure of much capital in their development. Charlotte county.

In the eastern part of the province, along the Bay of Fundy, Bailey, St. John and Albert counties. in the report just mentioned, records the presence of mixed copper ores at certain points, a short distance west of upper Salmon river, in Albert county, worked many years ago by the Williams Mining company, and by the Alma company; and to the Vernon Copper mine, on the shore of the bay, a few miles east of Martin head, opened by the St. John and Albert Mining company. Here chalcopyrite, peacock ore, and gray sulphide, occur in quartz veins, which traverse schists with intrusive diorites and other igneous rocks, and were mined quite extensively for a time, with very poor results. Indications of copper were also observed in this area, at Black river, as copper pyrites; at Goose river, as erubescite; at Little Salmon river, as native copper; at Martin head as chalcopyrite, and at West Beach.

In Carleton county, chalcopyrite was found at Bulls creek, a few miles south of the town of Woodstock, which was developed to some extent. Carleton county. In Kings county small quantities of copper pyrites were seen at several points, and in addition to the localities already mentioned in Charlotte county, its presence was reported at Adams, Simpson, Deer and Hardwood islands; at the entrance to Magaguadavic river; Moore's mills; St. David and St. Stephen. Most of these have been shown to be of but little value, while some were opened up and mined at intervals for some years.

The above list of localities shows that even at this early date the work of exploration had disclosed the presence of these ores at a number of widely separated points.

Report of
Prof. H. Y.
Hind.

Professor H. Y. Hind, in his extended report on the geology of the province, 1865, gives quite full details as to the working of several of the deposits mentioned, more especially as relating to the Vernon mine on the upper part of the Bay of Fundy. He also alludes to the presence of copper-bearing traps in this vicinity, which have recently been opened up by an American company, and in the northern part of the province gives further information relating to the ores found at Bathurst, Teteàganche; Campbell river on the Tobique where traces of the mineral were found in masses of igneous rock of that area; and to the ores of Bulls creek near Woodstock; as well as to the mines in the Letite peninsula.

The Letite
mine.

In the last named place, he describes the rocks as altered slates, often schistose, cut by numerous masses and dykes of diorite, and other igneous rocks. The copper is found unusually near the contact of the intrusives with the altered rock in the form of chalcopryite with iron pyrites and some native copper in the mass, described by Hind as following a line of fissure, holding calcespar, quartz and bitter-spar. Some of the schists are talcose and magnesian. Although opened by several shafts to a depth of over 100 feet and by tunnels driven off from these along the line of the supposed break, the quality of the ore did not seem to improve over the surface conditions, and work was abandoned.

The Vernon
mine.

Of the Vernon mines, Hind gives lengthy descriptions of the several veins and the mode of occurrence of the ore. He held that this was derived from masses of trap which intersect the schists of the area, and that the ores themselves were deposited in fissures as veins, the filling matter being calcite, bitter-spar and quartz. Chlorite is also found in some parts of the deposit. The place of working is in the side of a cliff facing the bay, difficult of access and with no facilities for shipment of the ores after mining. While some good ore was found in the veins, the quantity taken out was not sufficient to pay for the extraction, and this fact, together with the absence of conveniences for shipping, led to the abandonment of the area after the expenditure of a considerable amount of capital in development work. This area has again recently been opened up, but the details of work done have not come to hand.

In the report by Bailey and Matthew, 1870-71, a list is given of all known occurrences in the southern part of the province at that date. Of many of these, it may be here stated that they apparently possess no economic value, but are of interest merely as occurrences of

the ore under certain conditions. In addition to those already mentioned in previous pages are the following:—

West of St. John, along the shore of the Bay of Fundy.

Seely cove, copper pyrite (chalcopyrite) in chloritic and felspathic rock ; quantity small. Locations north shore of Bay of Fundy.

Seely cove, copper pyrite in chloritic and felspathic rocks.

Seely head, copper pyrite in red syenite and felspathic rocks.

Seely creek, copper pyrite in quartz veins in felspathic rocks.

Shore west of Crow harbour, copper pyrite and glance in quartz veins, cutting chloritic and felspathic rocks.

Cove of Red head, copper and iron pyrite disseminated in schist but no lode.

McLean's mills, New river, copper pyrite in quartz veins.

Negro harbour, copper pyrite.

Beaver harbour, copper pyrite in quartz veins in schistose diorite and with galena in chloritic and felspathic rocks.

Clarkes point, Mascarene, native and gray copper in trap with the reddish slates of this area.

Wheal Louisiana and Letite mines, copper pyrite and erubescite with diorite cutting hard slates. Passamaquoddy Bay mine.

Hardwood island, purple copper in strings and bunches in green chlorite slates.

Adams island, purple copper, veins in calcspar and quartz, with diorites, slates, &c.

Simpson island, copper glance and malachite with trap rocks and slates.

Campo Bello island, near Welshpool, copper and iron pyrite, with galena and blende in hornblende and slaty rocks.

Grand Manan, native copper and copper-glance in trap rocks.

In St. John county, east of St. John city.

Black River settlement, copper pyrite and malachite in hard clay slate with plant remains.

Bay of Fundy
shore, east of
St. John.

Little Salmon river, copper pyrite with iron pyrite in small quantity in slates.

Near Martin head, erubescite in schists.

Vernon mine, near Goose creek, erubescite, malachite, copper pyrite and cuprite in veins or fahl-bands with diorite, purple and gray mica slates, grits and conglomerate.

Point Wolf to Salmon river, erubescite and other ores, probably similar to those of Vernon mine.

Salmon river, 3 miles up from mouth, variegated and copper pyrite in dark slaty grits.

Blackwood block, malachite in hard gray slates.

Areas inland.

Beech hill, Westmorland county, copper glance in quartz veins, with fluor spar.

Kings Co.
areas.

Quispamsis, Kings county, copper pyrite, with blende and galena in gray chloritic gneiss.

Springfield, Scotch settlement, copper pyrite and glance in pale gray argillite.

London settlement, Kings county, copper pyrite in rusty-weathering sandstone.

McKenzies or Nerepis station, Westfield, copper pyrite with galena and iron pyrite in purple slates.

With the exception of the areas at Vernon mine and upper Salmon river, apparently no attempt has been made to develop these deposits, the economic value of which may be stated as small.

Simpsons
island.

Since the date of this last report some mining has been done at various points. In Passamaquoddy bay attempts have been made by several parties to locate the ore seen in a small vein on the beach, at Simpsons island, by sinking a shaft inland and driving towards it, so as to avoid the water which prevented mining operations at the earlier period. So far, these efforts have not been successful in finding any workable ore-body, though small irregular veins have been cut. The ore is of high grade, and when worked at the beach vein it is reported that 60 to 70 bbls. were extracted by Messrs. Lord and Dakin. The influx of water from the tides interfered so greatly with the progress of the work that it had to be abandoned. The last work at this place was about the year 1890, according to Bailey's Report (1897, Vol. VII.)

In the altered slates of Letite about three-fourths of a mile north of the post-office near the road to Back bay, recent attempts have been made to mine a deposit of copper similar to that of the old Letite mine. A shaft has been sunk to a depth of 140 feet in diorite near the contact with altered slates, the ore being a mixture of chalcopyrite with iron pyrite. As the shaft was filled with water during our visit in 1903, it was impossible to learn anything as to the actual copper contents on the spot, but there is no reason to doubt its similarity to those already mined and abandoned in the vicinity, and from the evidence obtainable the conditions are practically the same. The ore body does not appear to be sufficiently extensive to warrant expensive development. From our examinations of the district it would seem that the slates of the locality are of upper Silurian age since well defined fossils of that horizon are found at a number of places, and the alteration to pre-Cambrian looking schists is merely a local one and caused by intrusions of diorite and granite which have also been altered in places to green chloritic schists by the pressure which has affected all the rocks of this area. In fact it would appear that all the mineral occurrences of this district are due to the great period of igneous activity which affected the Passamaquoddy region. While traces of copper are found at a number of points in these altered rocks, at no point does there appear to be any largely developed ore-bodies throughout the area.

Letite mine.

About 1880 attention was directed to the presence of copper in the rocks of the ridge north of Dorchester. The formation includes sandstones and conglomerates of Millstone grit age which form a cliffy front of considerable elevation, resting upon red Lower Carboniferous marls or shales. In the lower part of the sandstone beds remains of plant stems are abundant, and a zone of these can be traced for a long distance following the face of the ridge. Where these remains are found copper has been thrown down from solution and parts of the plants are changed to lignite. The sandstone adjacent to the principal copper deposits is also charged with gray ore to some extent, portions of it containing from a half to three per cent in a fine state of division.

The Dorchester Copper mine.

Attempts to mine these ores were made about 20 years ago and the property was opened by a series of adits along the dip of the beds on which the ores were deposited. In places the showing is very good and a considerable amount of rich ore has been extracted. A shaft was sunk in 1884 to a depth of about 100 feet, when it reached the underlying red marls. Owing to the impossibility at that time of successfully ex-

tracting the disseminated ores by any known process, the property was abandoned. About three years ago another company began development work at this place and erected a large plant for the extraction of the copper by the electrolytic method. The rock was finely crushed and afterwards treated with sulphuric acid, the metal being then thrown down on metal plates as pure copper. While the extraction of the metal was successfully accomplished, the expense of its treatment was such as to preclude the possibility of any profits by this method and the work has again been abandoned. This deposit was first referred to in the Report for 1877-78, p. 120 D.

Indications of copper in nodules are found at several points along the shore below Dorchester on the west side of the Marangouin peninsula in the Lower Carboniferous rocks, under similar conditions to those just mentioned, but these are too small to be of any economic value. These ores are also found at a number of points between Dorchester and Sackville but, in so far as can be learned, will not repay the cost of extraction. Their occurrences are similar to those along the south side of Northumberland strait in Nova Scotia, already described.

On the whole, therefore, it may be said from a careful study of the New Brunswick ores that there is a marked resemblance to those of the adjacent province of Nova Scotia, both in the modes of occurrence and in their geological positions. The deposits of copper pyrites, associated often with blende and galena, are almost identical in character and associated rocks with those found in Cape Breton, and are too small in extent and too uncertain in their occurrence to warrant the expenditure of much capital in their development. Those of Passamaquoddy bay and Letite are similar to the ores of Antigonish county and like them have led to the expenditure of large sums in the difficult task of making them remunerative. The Carboniferous ores are practically the same for both provinces, and the expectation of finding large and valuable deposits has not yet been realized; while the attempt to mine the native copper of Grand Manan island, similar in most respects to that of the North Mountain range of the Bay of Fundy, has long since been abandoned. The latest attempt to mine the ores of the igneous rocks of eastern St. John county, which are in spots rich in copper is as yet in the development stage only, and but little can therefore be said as to the true value of this locality.

General
character of
the ores.

QUEBEC.

The copper ores of Quebec are of a somewhat different class from those already described for the eastern provinces. In their mode of occurrence they are usually associated with intrusive rocks, but these occur with older formations and are practically confined to the Pre-Cambrian, probably Huronian, series and to certain parts of the Cambrian system, more especially to that portion which has been described under the head of the "Sillery formation."

Copper ores
of Quebec.

The occurrences of these ores were given in considerable detail in the report "on Mineral Resources of Quebec" 1888-89, by the writer, and though some development work has been carried on since that date, sometimes by re-opening mines there described and which have been closed for some years, and partly through the discovery of new localities at widely separated points, the general statement as there given cannot be greatly changed. Recent work by Professor Dresser, who has recently been investigating the copper-bearing rocks of the Eastern Townships, has furnished new light as regards the origin of certain of the copper belts from the petrological stand point, and shown that in some cases rocks which were at one time regarded as altered sediments are apparently rather altered eruptives to which a bedded aspect has been imparted by pressure or other agencies. In addition also to the statement given in the report of 1888-89 that these ores were referable to three principal belts, Mr. Dresser has indicated a fourth belt which comprises the ridge of crystalline rocks along and near the boundary between this province and the State of Maine. At the time of writing the report in question however the presence of ore-bodies was pointed out at several localities in this district, more especially with regard to the presence of galena and pyrites ores, so that the later discoveries, which will be referred to again, are to some extent due to the settlement of the country whereby greater facilities for examination have been presented.

In view of these facts the remarks on these ores contained in "Mineral Resources of Quebec, 1888-89" are quite as applicable at the present time as they were at the date when written, and they may be here introduced with the addition of such matter pertaining to the subject as may have developed since that time.

Report on
Mineral
Resources
1888-89.

While we have seen that the presence of iron ores in workable quantities was known in eastern Canada more than two hundred years ago, and that they have been utilized for nearly a century and a half in the manufacture of iron, the first reference to deposits of copper

First discoveries, Geol.
Sur. Rep.
1847-48.

ores in the province of Quebec is apparently that contained in the report of the Geological Survey, 1847-48, where, on pages 26-27, the occurrence of copper pyrites is noted in connection with the limestones of Acton, Upton and Wickham, and further north in Inverness. Reference was however, made in 1830 by Gen. Baddeley, R. E., to the copper ores of western Ontario, but at this date it does not appear that anything was known in relation to those of Quebec. As regards the deposits observed in Quebec, and referred to by Sir William Logan in the report just mentioned, the quantity was generally regarded at that time as unimportant; but several localities were recommended for trial. Among these was a quartz vein on lot four, range two, of Inverness, having a thickness of about two feet, with a course a little north of east, which, however, upon testing, (although the quality of the ore was excellent), did not appear to contain sufficient to render its further exploration profitable.

Ores of Ascot
and Upton.

A second area recommended for trial at the same time was the seventeenth lot, seventh range of Ascot, about one mile from Sherbrooke, on the road to Lennoxville. The thickness of the quartz vein here carrying copper pyrites was from ten to twelve inches, cutting chloritic and talcose slates, and it carried, in addition to the copper ore, small quantities of gold and silver. The third locality recommended was in the fifty-first lot of the twenty-first range of Upton; the breadth of the lode, which is in a whitish gray massive limestone, being from twelve to eighteen inches, consisting of white quartz and calcspar, carrying pyrites also in small quantity. Assays of the ores from these three localities were made by Dr. Hunt. The percentage of metallic copper in the washed chalcopyrite from Ascot was 30.34, or eighteen per cent. of the vein; from Inverness, 34.93, or seven per cent. of the unwashed ore, and from the Upton lode, from an average sample, 3.84 per cent.

Geol. Sur. Rep.
1849-50.

In the report of 1849-50, reference was made to traces of copper in the rocks of the Chaudière river, in the seigniorie of St. Joseph, where in rear of the church at that place, spots of vitreous copper were found disseminated through quartz veins in red and green slate, and again at about one mile from this river on the road to Frampton. Similar ore, in quartz veins in the red slates, was also at the same time noted as occurring in Ste. Mary's seigniorie; but neither of these localities appeared to possess any special value. The deposit at Upton was opened up and found to consist of a series of bunches, following a bend in the stratification; but the opinion was expressed that their irregularity was such as to seriously interfere with their being successfully worked for copper.

The copper deposits of the eastern townships appear to have been entirely neglected for some years after this, but some examinations made about this time on the north side of the St. Lawrence, in the augmentation of Lanoraie and Dautraye, on the left bank of the L'Assomption river, showed the presence of a vein nine inches thick of coal and pearl-spar, cutting gneiss, which carried copper and iron pyrites. On either side of the main vein, other veins were reported of an inch or more in thickness, also carrying copper pyrites, and the whole group was comprised in a breadth of about nine feet. In this a shaft was sunk for sixteen feet, the veins, which had the aspect of regular lodes, appearing uniform throughout, though the quantity of copper they contained did not seem to be remarkably promising.

Areas North
of the St.
Lawrence.

A more detailed description of the Upton deposit appeared in the report for 1858. It is there stated to occur in a mass of grayish-white, sometimes reddish-gray limestone, compact sub-crystalline and yellowish-weathering, reticulated by small veins of copper pyrites, as well as by others of quartz and various ores of iron, all of which were regarded as of a segregated origin. This ore-bearing limestone was overlaid by a bed of breccia, or conglomerate, which also carried pyrites and was supposed to be underlaid by reddish-gray limestone, which, towards the bottom, became interstratified with red slates. No copper was found in the underlying limestone. The general dip of the measures was to the south-east at angles of 10° to 27°. The bands of limestone, carrying ore, extend through the northern part of Acton into Wickham where, also, on the twenty-sixth lot of the last range of that township, they also carry similar ores. A second band to the south-east is seen at Acton on lot thirty-two of the third range, which extends approximately parallel to that just mentioned, and also at Wickham, and this was regarded as the equivalent of the Upton bands of rock coming to the surface on the south side of the synclinal.

The Upton
mines.

The description of the rocks of this copper belt is considered of some importance, as illustrating a peculiar series, in which has occurred, more particularly at Acton, and presently to be described, one of the most productive copper mines ever worked in Quebec; a band entirely distinct in character from those which contain the copper deposits now so extensively worked in the eastern townships. In order that the relations of the several ore belts may be better understood, we may here proceed to describe, before taking up the history of the several copper mines, which nearly thirty years ago were so prominently before the mining public, the views of structure of the several areas of cupriferous rocks, as stated in the *Geology of Canada*, in 1863 and 1866, more

especially since the new views of the structure and of the age of these rocks, as stated in the more recent reports, have modified the opinions there expressed to a very considerable extent.

The metamorphic rocks of eastern Quebec were, for many years, regarded as the altered equivalents of the fossiliferous and comparatively unaltered sediments of the St. Lawrence basin ; and these were divided at first into two and subsequently by sub-division into three portions, viz. : The Levis, Lauzon and Sillery formations.

Character of
the copper-
bearing rocks.

These were supposed to be arranged in a series of long and sometimes narrow folds, with many overturn dips, of which it was remarked that "the latter circumstance renders it difficult to determine which of these folds are synclinal and which anticlinal, inasmuch as the outcrop in both cases presents a similar arrangement." These metamorphic rocks, for the portion north of the Vermont boundary, considered to be specially cupriferous, were held to occur in three approximately parallel bands or areas. Thus the first area, or the most westerly, extended from Farnham, near Missisquoi bay, to the seigniory of Lauzon, on the St. Lawrence. Where it is traversed by the St. Francis river it was supposed to be nearly, or quite, separated into two parts by the appearance of what was then regarded as the underlying series of slates. In this supposed synclinal are found the deposits of Upton, Acton, Wickham, Roxton and Durham, while in the north-eastern extension are those of Wendover, Somerset, Nelson and St. Flavien. The second area, which was supposed to be divided into two parts by the ridge of the Sutton mountain, extended from St. Armand to the seigniory of Ste. Mary, on the Chaudière. In this were the copper deposits of the townships of Sutton, Stukely, Melbourne, Cleveland, Shipton, and further to the north-east those of Halifax, Leeds, Inverness and Ste. Mary.

Three areas.

The western portion of this supposed synclinal occupied the Sutton valley ; the eastern, the Potton and Bolton area along the valley of the Missisquoi river. The third area extends from Owls head on Lake Memphremagog to the township of Ham, and included the Stoke mountain, while further to the north-east, it was traced across the Chaudière into Buckland. It was supposed to be separated from the last by what were regarded for the most part as newer rocks, much of which were supposed to be of Upper Silurian age, although now known to belong, in great part, to much older horizons. In this area were included the deposits of Ascot, Ham and Garthby.

The rocks of the first or most westerly area, extending from Farnham north-easterly, were regarded as belonging to the Lauzon

and Sillery divisions of the Quebec group. They include slates, black, red, green and gray, with sandstones, diorites and dolomitic limestones ; which are seen at many points. The outcrops at Upton and Acton appear to be very similar in character, and probably represent portions of the same series, brought to the surface by synclinal structure. Of the second main synclinal, as then considered, viz., that in which the Sutton mountain was supposed to occur, the rocks vary somewhat on either side of the mountain ridge ; those on the west being, for the most part, schistose and crystalline, either talcose, micaceous or chloritic ; while on the east side there is a large development of serpentines, diorites, slates and hard quartzite. The rocks which were found in the third area, or that of Ascot, were also largely schistose, resembling rather those of the western side of the Sutton mountain than of the eastern. It will be seen, therefore, that there is a manifest difference in character of the rocks in the three areas, and by a careful examination of the copper ore obtained from each of these, a corresponding difference in their character will also be observed ; the ore of the Ascot belt being unlike that from the Potton area, while this in turn is of a different character from that of Acton or Inverness and Leeds.

Rock of the first or most westerly area.

The studies made of these several groups of strata during the past ten or fifteen years have led to an entire change of opinion regarding their relative ages and structure from that expressed in the Geology of Canada, 1863. Instead of now regarding these different copper-bearing belts as synclinals in the Sillery or other divisions of the Quebec group, and all of Lower Silurian age, it is now very clearly established that while the rocks of the first area are, in large part, of the same age and character as those which have been described as the Sillery formation, and which is now held to form the lowest member of the fossiliferous Quebec group, as developed along the south side of the St. Lawrence river, those of the second and third areas, or of Sutton and Ascot, belong, for the most part at least, to the pre-Cambrian horizon ; while the slates and serpentinous or dioritic portions may probably, with more propriety, be classed in the lower portion of the Cambrian system, the slate rocks of which flank the pre-Cambrian schists on either side, and that the greater part at least of these crystalline schists really occur as anticlinal axes instead of as synclinals of altered Lower or Middle Silurian rocks.

Change of view as to age of the rocks.

As just stated, the characters of the ores in the different copper-bearing belts,—for it is scarcely necessary to maintain the use of the term synclinal in view of the change of opinion expressed—varies greatly

Ores of the
first belt.

when contrasted. Thus, from the more westerly belt, the ores are largely yellow sulphides, though occasionally varied sulphides are found, mostly in a dolomitic limestone. In the township of Roxton the principal deposit was on lot twenty-three, range three, where the ore, according to the late Mr. Charles Robb, M. E., who had great experience in the mines of this section of Quebec, appeared to be disseminated through a band of this rock for a breadth of fifty feet, but was more particularly concentrated into a breadth of about one foot near a band of diorite. From the west half of this lot, belonging to Lord Aylmer, there had been obtained in January 1864, fifty-six tons of three and a half per cent. ore, sixteen tons of five per cent. and two tons of twelve per cent. ore; and from the eastern half, eight tons of eight per cent. and fourteen of three and a half per cent. were taken. In the adjoining township of Ely, though indications of ore are found at a number of points, the principal deposit was on lots nine and ten of the second range, owned by the Ely Copper Mining Co., where the ores were the yellow and variegated sulphides in a crystalline limestone. In Upton, mining was carried on at four places, viz. 1st, on lot forty-nine of range twenty, called the Bissonette mine, where there was a yellow sulphides in a thickness of three feet and a half of dolomite, yielding from 10 to 15 cwt. of 10 per cent. ore per fathom. 2nd, at the Prince of Wales mine on lot fifty-one of the same range, (the ore being scattered through about twenty feet of the same band as the last) from which about forty tons of twelve and a half per cent. ore were obtained from open cuttings. 3rd, on lot forty-nine, range twenty-one; the ore and rock being similar to the last, and owned by Col. McDougall, by whom, from open cuttings also, about twelve tons of twenty per cent. ore and eight tons of twelve per cent. were obtained; and 4th, the Upton mine, on lots fifty and fifty-one of the same range, where two shafts were sunk to depths of forty-two and twenty-five feet respectively, which yielded a considerable quantity of ore, the exact amount, however, not being stated.

In the township of Acton several mines were located and worked to some extent about this time, but of all these, the one known as the Acton mine, situated on the thirty-second lot of range three, and about half a mile south of Acton station on the Grand Trunk railway, was the most important.

The Acton
mine.

The discovery of this mine is said to have been made by Mr. H. P. Merrill, but the date of this discovery is not mentioned. In a paper by Mr. Robert Williams, for many years connected with copper mining in eastern Quebec, read before the Lit. and Hist. Soc. of Quebec, 1865, we learn that in the autumn of 1858, operations were com-

menced by Mr. Sleeper ; and 'that although the discovery of copper ore of very rich quality was known some years previously, so incredulous appeared the human mind on the subject, that the property was purchased by Messrs. Davis and Duncan, of Montreal, from the owner, Mr. Cushing, of Actonvale, for a very insignificant sum and a royalty, but these gentlemen had so little faith in their purchase, that they at once leased it to Mr. Sleeper on tribute, at two-thirds of all the ore that he could obtain from it for a period of three years.'

It was largely in consequence, apparently, of the good results obtained by Mr. Sleeper at this mine, that the great boom in copper mining and exploration took place in the townships, which resulted in the finding of the ore in greater or less quantity at hundreds of places throughout the areas already outlined, and of which a full list of localities will be found in the report of the Geological Survey for 1866, prepared by Mr. James Richardson.

The peculiar character of the deposit at this place, and the great importance which for some years attached to this mine renders it worthy of a somewhat detailed description. When first found 'the surface presented an accumulation of blocks of copper ore, evidently in place, and covering an area of about sixteen paces in length by ten in width. These masses consisted of variegated sulphuret of copper, intermingled with limestone and a siliceous matter, without anything like veinstone, and evidently constituted a bed, subordinate to the limestone, whose strike was about north-east, and with a dip to north-west at an angle of about forty degrees. In continuation of this bed, for about seventy paces in either direction, the limestone was observed to hold little patches and seams of variegated ore and yellow pyrites, with stains of the blue and green carbonates of copper. The limestones in the immediate vicinity presented several veins of quartz crossing the strike, but containing only traces of copper.' * Mode of occurrence of the ore.

The mine was worked by Mr. Sleeper to September, 1861, when it reverted to the proprietors, Messrs. Davis and Duncan, of Montreal, by whom it was sold, in October, 1862, to the Southeastern Mining Company of Canada. The enormous masses of rich ore-bearing rock gradually became exhausted, though no attempt at any very deep exploratory works appears to have been undertaken. According to Mr. Richardson's notes, the mine produced, during the period in which it was worked, 16,300 tons of 12 per cent. ore, sent to market, besides a great amount of a lower grade left at the surface.†

* Report Geol. Survey, 1858, pp. 57, 58. † Report Geol. Survey, 1866.

Mr. Thos.
Macfarlane's
views.

The ore at this mine, from a number of sections furnished by Mr. Thos. Macfarlane, who was in charge of operations there for some time, and who published an exhaustive paper on the subject in the *Can. Nat.*, 1863, is apparently for the most part confined to a bed of dolomitic limestone interstratified with dark gray shales, a considerable thickness of which lies between the copper limestone and a great mass of another limestone band, which forms a prominent ridge to the south of the workings. Between the copper limestone and the shale beneath, intrusions occur, often of considerable size, of a greenish fine-grained diorite, which are also at times found above the limestone band. The strata, both above and below the limestone band, also contain small strings of copper pyrites, but the workable deposits are for the most part confined to the calcareous portion. The cupriferous rocks appear to be bent in an anticlinal fold, and are, to some extent, affected by faults; these being probably due to the diorite intrusions.

Ore in lime-
stone asso-
ciated with
diorite.

The bed of limestone, which appears to have carried the bulk of the ore, appeared in places as a solid mass, at others as a brecciated rock or a conglomerate; the latter consisted of the pyritous, the variegated and the vitreous ores disseminated through the brecciated bed, constituting, to some extent, with silica, the paste of the mass. The ore deposit at Upton presents a somewhat similar set of conditions, with this important difference that, while at Acton the prevailing ores were vitreous and variegated, at Upton the ore was mostly chalcopyrite.

If the two localities of Upton and Acton should be the outcrop of the same beds on the two sides of a synclinal, it is very possible that other large deposits of similar ores may occur besides those already worked. To test this point at Acton would, however, require considerable expense for shafting. Several bore-holes have been put down, but the results obtained have not been made available. From the fact that red slates of the Sillery formation cross the Grand Trunk railway a short distance east of this mine, and appear, also, near the village of Acton, as well as in the lower beds of Upton, it is probable, that the unusual development of copper is in rocks of Sillery age, and that its presence is here due to the intrusion of dioritic matter since at other localities in this formation, as at Nelson, St. Apollinaire, &c., though the amount of copper is not so large as at Acton, the presence of diorite masses at these places, in somewhat similar rocks, has apparently produced similar effects, though on a much more limited scale.

Among other localities in Acton township where exploratory work was carried on about this time, were lot thirty-one, range four, called the Vale mine, the results from which were of little value; and the White Horse mine on lot twenty-nine of range six, and on lot thirty-one of range three, the ores being similar to those of the Acton mine, and, as at that place, occurring in dolomite. It is probable that the diorites were absent from these localities, no mention being made of them at either place. In Wendover, in the diorites which cross the St. Francis from the town of Drummondville, several shafts from 30 to 40 feet in depth were sunk between 1860 and 1863 by the Drummondville Mining Co. of Canada, but without finding copper in any quantity, though just before the suspension of the company a large vein was reported to have been struck. Since the failure of the company no further attempt has been made to ascertain its value.

Drummond-
ville mine.

In Wickham two mines were located. The first and most important, was styled the Wickham mine, on lot fourteen, range ten; the ores being yellow and variegated sulphides in dolomite. Here a shaft was sunk to a depth of thirty feet and a few tons of ore removed. The Toomey mine, on the third lot of the eleventh range, was in similar rock of ore, but the work done was merely exploratory and confined entirely to the surface.

In the township of Durham, adjoining Acton, ores of the same character are found. Two mines were here started, of which that on the twenty-first lot of the seventh range, styled the Durham mine was apparently the more important. Shafts were here sunk on three veins, varying from three to twelve inches in thickness, the deepest shaft being eighty-four feet and ending in black slate. The ore obtained amounted to ten tons of five per cent., 110 tons of three per cent., and 300 tons of one per cent., consisting of yellow sulphide in a calcspar vein cutting dolomite. On lot nine, range six, a shaft was also sunk to a depth of sixty-four feet in similar ore, but no returns are given; and on the south-west half of lot nine, range four, a shaft was sunk to a depth of forty feet, showing good specimens of the variegated and yellow sulphides, while a second shaft of sixty feet was sunk on the north-east quarter of the same lot, in green and black slates, for which no returns are available.

Mines of
Durham.

In Somerset, near the northern portion of this area, small quantities of the yellow sulphides have been observed in beds of limestone conglomerate near diorites; and in Nelson, on lot eight of range eleven, the yellow and variegated ores are disseminated through limestone, also near diorites, from which about ten tons were extracted by a

company formed in Boston. The width of the ore-bearing bed was about thirteen feet. At various points along this line also, indications of ores, for the most part similar to those already described, but presumably in even smaller quantity, were observed. In the county of Lotbinière, near St. Apollinaire, indications of the yellow sulphide are found in amygdaloidal diorite; and in this vicinity the St. Flavien mines were worked about thirty years ago. Since that time no attempt at exploration in any part of this area appears to have been made.

Copper ore
associated
with diorite.

Throughout the rocks of the western division, the workable deposits of copper also appear in all cases to have been associated with masses of intrusive diorite, which have penetrated the red and green slates and limestones of the Sillery formation, now regarded as forming the upper portion of the Cambrian system. The want of success which has attended many of these workings is due largely to decline in the price of copper, and also to a lack of concentration of the ore in the cupriferous beds, since the quality of much of that obtained is excellent and in some cases peculiarly rich, as seen in the Actonvale deposits.

Mines of the
second or
middle belt.

Of the mines found in the second belt, beginning at St. Armand, it may be remarked that the ores here observed, differ somewhat both in character and mode of occurrence, and, as already pointed out, in the nature of the containing rock. In this area, at the time of the great copper excitement, several localities were indicated in which traces of the metal, both as sulphides and carbonates, the latter in green chloritic and epidotic rock, were found, but none were at that time shown to be of much importance. In 1882, however, a vein of yellow and variegated ore was opened on the south side of the Pinnacle mountain, St. Armand, in greenish micaceous and chloritic schist, which was worked for some time, and at first promised well. Crushing and concentrating works were erected, and a considerable quantity of the ore extracted and prepared for market, but the works were shortly afterwards abandoned, and no returns from this location are at hand. In the township of Sutton, adjoining, copper mining was carried on at a number of points; indications of the presence of the ore being frequent. These ores were mostly the yellow sulphide, but green carbonate of copper, with deposits of the variegated and vitreous ores, were frequently observed. Among the most important of these in this township, and which have been opened up to some extent, may be mentioned the following:—

Sweet's m. ne.

Sweet's mine, on the west half of lot eight, range ten, where variegated and vitreous sulphides occur in a bed of nacreous schists from one to four feet and a half wide, which, for the whole breadth,

yielded four and a half per cent, of copper. A band of dolomite occurs in the vicinity, but the ore is confined principally to the schists; differing in this respect from those of the first belt, of which the Acton mine may be taken as the type. This mine was one of the first opened in this portion of Quebec; samples being displayed at the International Exhibition in London, 1862. The schists in which it and the mine on the Pinnacle are located, belong to a distinctly lower geological horizon than that of the belt just described from Farnham, north. A considerable quantity of ore was raised from the Sweet mine, but probably the limited size of the lode interfered with its successful development.

The works of the North Sutton Mining Co. were located on the north half of the eleventh lot in the tenth range, on a bed from eight inches to two feet thick, in talcose slate, near black plumbaginous slate. Three shafts were sunk, one of which was twelve feet deep, and about two tons of five per cent ore were obtained. Explorations were also carried on by this company on a seven feet vein in nacreous slates, on the west half of lot twelve, range eleven, carrying yellow sulphide with iron pyrites, but no returns are at hand from this exploration. Two shafts of a depth of fourteen and nineteen feet respectively, were sunk. Sutton.

On the east half of lot nine, range eleven, the Brome Mining Co. also sank a shaft sixty feet deep on a bed of variegated and vitreous ore in similar nacreous slates, of which it was supposed three feet of the rock would carry three per cent ore. From this also no returns are available, and in the south-east half of lot seven, same range, explorations on a four feet band in chloritic slates yielded, according to Mr. Chas. Robb, a considerable quantity of ore.

In the adjoining township of Brome, mining was carried on at several points. Brome. On the east half of lot five of the fifth range, the yellow and variegated sulphides were found in three bands, varying from two to thirteen feet thick, supposed to be repetitions of one and the same bed through undulations of the strata. Three shafts were here sunk by the Canada Copper Mining Co. to a considerable depth, and a large quantity of ore, estimated to grade three per cent, was extracted. Machinery for crushing and concentrating was erected, but the company soon ceased operations. On lot six, range six, considerable exploratory work was carried on by the Bedford Mining Co., but with no satisfactory result. On the west half of lot twelve, range seven, the Tibbets mine, owned by Messrs. Ball and Morell, consisting of a shaft eighteen feet in depth, was sunk on a band of yellow sulphide

in nacreous and chloritic schist. On lot six, range seven, the variegated ore was found in two bands, one of which, two to three feet thick, was estimated to carry one per cent of copper, the other band of five feet was supposed to carry one and a half per cent ore.

On lot eighteen of range eight variegated and vitreous ores were observed to occur in four bands in nacreous, chloritic and epidotic slates, and dolomite, in a breadth of several yards, and a small excavation, not sufficient for a test, was made. These ores were continued on lot nineteen of the same range, and on lot twenty-one, range nine, but no returns as to value or output from any of these are at hand.

Shefford.

In the township of Shefford, mining was carried on at two places only, viz., by the Glencoe Mining Co., on lot seventeen, range two, where the different ores occur with quartz and calcspar in four separate bands in micaceous and chloritic slate, and on lot twenty-eight, range three, by the Waterloo Mining Co., in similar ores, and with similar country rock, where a shaft was sunk to a depth of sixty feet, but no returns are available.

Stukely.

Further north in Stukely, the Grand Trunk mine was situated in the south-east quarter of lot six, range one. A shaft was here put down to a depth of sixty feet on a band containing yellow and variegated sulphides, in micaceous and chloritic slates, with dolomite of the usual character. The same bed, with a thickness of three feet, was found on the lot adjoining; some good ore was obtained, but the quantity is unknown. A trial shaft, twenty-one feet deep, was also sunk by Messrs. Lambe and Shepherd in the south half of lot seven, range two, on a band of fifteen to twenty feet of dolomite, carrying disseminated yellow ore with pyrites. On the south-east quarter of lot nine and the south-west quarter of lot ten, range six, vitreous sulphide occurs in chloritic sandstone associated with quartz, feldspar and chlorite; masses of pure ore being obtained weighing from three to twelve pounds. On the latter area the Logan mine was located, in which from four to five tons of twenty per cent ore were obtained.

On lot seven, range eight, two parallel bands of dolomite, carrying vitreous sulphide occur, with a breadth of twenty-three and thirty-six feet respectively, separated by about a hundred and seventy-five yards of micaceous and chloritic slates. The ores are intimately associated with veins and strings of quartz, calcspar, chlorite and epidote. A shaft was sunk for sixty feet and a cross-cut driven twelve feet across toward the vein to the west, but did not reach the ore. On the north-east half of lot six, range nine, a shaft was sunk for one

hundred and forty-two feet in a slate band, carrying similar ore to the last, without satisfactory results, and on the south half of lot four, tenth range, a shaft twenty-two feet deep was sunk in order to cut a band eighty to ninety paces wide, in which four cupriferous bands occur. No returns from any of these are available.

Tracing this belt to the north, we have, in Melbourne, several deposits Melbourne. of copper ore, for the most part in green chloritic rocks and micaceous schists. On these deposits three mines have been in operation, viz., the Ryan Hill, the Cold Spring and the Balrath. The first is situated on lot two, range two; the ore is the variegated and vitreous sulphide in chloritic slates; the size of the band has not being stated. At the Cold Spring mine, lot six, range two, some shafting was done; the ore occurred in narrow bands over a considerable breadth, but presumably not in sufficient quantity to be economically valuable. At the Balrath mine, on lot two, range four, the ore, which is of the kind just described, is said to occur in a series of bands, eight in number, ranging from one and a half to five feet in width, in one of which a shaft was sunk, which disclosed some rich bunches of ore. Considerable exploratory work was also done on lot eight, range one, in the shape of pits and trial shafts, on a deposit of yellow sulphide; the ore being mixed with magnetic and specular iron, in a gangue of quartz and calcespar, cutting quartzite and talcose slates. None of these areas appear to have yielded very much copper.

In Cleveland, across the St. Francis river, variegated and vitreous Cleveland. ores also occur, with similar chloritic rocks, at a number of places. The only locations worked to any extent, however, were on lot twenty-five, range twelve, at the St. Francis mine, and at the Jackson mine, on the south-west quarter of lot twenty-six of range thirteen. At the former place, in addition to the usual ores already mentioned, green and blue carbonates are said to occur with a little native copper; the whole contained in a lode three feet thick. A shaft was here sunk for 195 feet, and levels and other works driven for 513 feet along the lode, from which a large quantity of ore was taken, which, according to Mr. Bennett, the manager, ranged from six to twenty-six per cent. At the Jackson mine a shaft was sunk to a depth of twenty feet, the ore being found in a lode one foot in width, with other veins carrying ore in smaller quantity at no great distance from it. The amount of ore extracted from either of these places is not known.

In Shipton, copper ores are comparatively rare, at least in so far as Shipton. known, and not in sufficient quantity apparently to warrant mining operations; but in Halifax the variegated and vitreous ores are again

quite extensively distributed, the rocks being schists of the same character as in Melbourne. Mining was carried on at two places, viz., by the Halifax Mining Co., on lot ten of range three, where a considerable admixture of different ores was found in a vein from eight inches to three feet in width, on what is known as the Halifax mine, and visible gold was reported in a quartz vein which was cut. Considerable work was done here by shafts and adits, but no returns as to the amount of ore obtained are at hand, though no large bodies of it were found. At the Black Lake mine, on lot nine, range nine, some exploratory work was also done by Dr. James Repd and others, but nothing of importance was encountered.

Chester.

In Chester, although exploratory work was carried on at a number of points, the most important location probably was that in the S. E. half of lot eight, range six, known as the Viger mine. Here the ore was principally the yellow sulphide in quartz veins, and vitreous ore in the slates. The veins were scattered through a width of 170 feet and were opened at a number of points, from which a considerable quantity of ore was extracted, but involving a large outlay and much work. No deposits of large size were met with, and the explorations, after a very thorough trial, were found to be unprofitable. The metaliferous veins on this property extend across into the adjoining lot, but their size was insufficient to pay for the labor involved in the opening. On lot nineteen, range ten, the Austin Mining Co., made a couple of openings, one on a two-foot vein, the other on one of six feet, but the ores were found to be not sufficiently concentrated in the gangue to pay for extraction. Explorations were also made on lots eleven and fourteen of Craigs Road range, in variegated and vitreous ores in limestone, but without success, as well as on lot five, range six, where a quartz vein from two to four feet thick was observed, which presented some good specimens of ore, but the quantity was too small for successful mining.

Inverness.

Ores similar to the last are found at several points in Inverness, occurring in micaceous, chloritic and nacreous slates or schists, but, in so far as known, no attempt at mining them was made, though one of these localities was among the first recommended for trial in 1847. In Leeds, however, in addition to the great Harvey Hill mine, very fully described in the Geol. of Can., 1863, several other deposits were worked, notably that on the fifteenth lot of the fourteenth range, in close proximity to the Harvey Hill deposit, the veins and ore beds from which, were supposed to be continuous in this direction. The ores are all vitreous, variegated and yellow sulphides occurring in beds or

veins, in what have been styled nacreous slates, and, on the lot just mentioned, they were owned by the English and Canadian Mining Co. Native gold was found in one of the ore veins. Not far distant from this, to the north-east, in that part of the seigniory of St. Giles known as the Handkerchief, the Chaudière Mining Co., opened up several quartz veins, of which eight were exposed in a breadth of 1,100 feet, two of which had a thickness of two to three feet, and could be traced for 1,200 to 1,500 feet. About \$5,000 were spent in these explorations, but owing to difficulties of various kinds, the work was shortly abandoned. Fine specimens of ore were obtained here, and the quartz is reported by Dr. Reed to have yielded him native and visible gold.

What was regarded as the eastern limit of the second belt was the seigniory of St. Mary, where ores similar to those just described occur in red and green slates near ferruginous dolomite, not far from St. Mary's church. From the aspect of the strata, it would, however, almost appear as if this deposit should be more closely related to the red slates and dolomite of the first area. Another mine at St. Sylvester, referred to in the report of the Geol. Survey for 1866, was that of St. Margaret. It was opened by the late Thos. Glover of Quebec, by whom a company was formed in New York, styled the St. Margaret Mining Co. Several shafts were sunk with an expenditure of about \$5,000, the amount of ore obtained being about fifty tons. The ore was mostly the variegated sulphide, the country rock consisting of purple slates, green grits and quartzites. The mine was owned by Mr. Cromwell, but the ore appeared not to be in sufficient quantity for profitable extraction.

The most important of the mines in this section, is that so widely known as the Harvey Hill, now the Excelsior, on lot seventeen, range fifteen, of Leeds. This location, according to a paper by Mr. Herbert Williams read to the Literary and Historical Society, Quebec, 1865, was the second discovered in the province as carrying copper, the first found having been at Inverness. These discoveries did not appear to awaken very great interest for some time, and Dr. James Douglas seems to be the first who appreciated their value, and through his agency the Megantic Mining Co. was formed for the purpose of exploring and working the copper deposits of Megantic county. Upon the discovery of the Harvey Hill deposit, the location was secured by this gentleman and his associates, who organized a company under the name of the Quebec and St. Francis Mining Co. Little further investigation was, however, undertaken by any others except this company, who explored the Harvey Hill property in

The Harvey Hill mine.

Early history. such a way as to bring it prominently to the notice of English capitalists, and by these a new company was formed in 1858, under the name of the English and Canadian Mining Co., by whom operations were commenced and carried on with varying success for a number of years. The history of the workings of this celebrated mine for some years is given in the Geol. of Can., 1863, with considerable detail. From this we learn that the ores occur in two ways, first as a series of interstratified beds, of which three were clearly recognized, varying in thickness from six inches to six feet, or possibly more, and second, in lodes or veins, composed of quartz, with calcite, pearl-spar and chlorite, some of which carried the variegated and vitreous ores; others carried copper pyrites, in places, in very rich pockets. The veins which sometimes cut across the bedding, were exceedingly rich in certain parts, and in others comparatively barren, so much so that in actual value as a source of supply for copper, the beds were considered the more important. In these the various ores were disseminated through the body of the slates, generally in lenticular masses, running with the bedding. These masses were generally small and thin, sometimes having a thickness up to three-fourths of an inch, with a length of six to twelve inches, in addition to scattered grains of the ore through the slate bed; the amount of copper in all being estimated at from three to five per cent.

Exploration. The hill upon which this mine is situated was pierced by a number of shafts from twelve to forty-five feet deep, as well as by tunnels and an adit; the whole forming a very extensive series of workings. The principal adit was driven into the hill across the measures for a distance of 1,488 feet and intersected the several ore beds, the upper one of which had a thickness, when first worked, of three feet, which, in the lower workings, increased to ten feet and was estimated to carry five per cent. ore. From a prospectus issued by the Consolidated Copper Co. of Canada, limited, in 1872, the subsequent history of this mine is given to that date. The surface works of the company, including much of the plant, were destroyed by fire in 1866, with an estimated loss of £20,000, owing to which, operations were suspended till 1870, when Dr. James Douglas, one of the proprietors, took over the work again and resumed operations in the mine. The quantity of ore raised from the commencement of operations in 1858, to the end of 1862 was 322 tons containing thirty per cent. copper, in addition to 1,000 tons at the surface of two and a half per cent. and 500 tons of four to five per cent from the upper bed. The figures as to the output for the different years, as given by Mr. H. Williams, the manager, are as follows:—

Output.

	TONS.	CWTS.	QTRS.	LBS.	
1858.....	9	15	0	2	} of 30 per cent. copper.
1859.....	43	7	0	21	
1860.....	104	5	3	0	
1861.....	70	4	1	6	
1862.....	94	17	2	21	} of 26 per cent. copper.
1863.....	113	20	3	14	
1864.....	235	12	3	4	
					of 20 per cent. copper.

The mining ton = 21 cwts., or 2,352 lbs.

The falling off in the value of per centage is attributed to the fact that during the last years the mining was confined principally to the beds and not to the quartz veins. The ore in these beds was found by Mr. Williams, upon careful examination, to occur in lenticular masses, as already stated, varying in thickness from one-sixth of an inch to two or three inches, and in length from three to eighteen and even twenty-four inches. These masses overlapped each other and were disseminated throughout a thickness of five to six feet. This refers to the overlying or upper bed, which appears to have been the one principally worked. For 1865 the figures for the output seem to be wanting, but from the report of Mr. Harrold Douglas, superintendent of the mine, as given in the prospectus of the Consolidated Co. mentioned, it appears that for a part of 1866, in which year the works were destroyed, 265 fathoms of ore were taken from the bed, dressed to twenty-four per cent and sold in Liverpool for \$35,420, being an average of fifteen shillings per unit. From a paper by Mr. James Douglas, jr., of Quebec, in the Lit. and Hist. Soc. of that city, 1870, in discussing the several beds from which the supply of ore had been principally derived, he considers that 'there is no likelihood of these beds being of such great extent or of such uniform richness as was at one time attributed to them.'

The work of Mr. Williams on the main or upper beds showed that where quartz lodes cut the beds, deposits of ore, often of considerable size and great richness, were struck; that the beds gradually became less rich in copper as they were worked away from the lodes which had all along been supposed to derive their supply of ore from the beds with which they were associated; but certain features observed in driving an inclined shaft on a lode, reached from the Kent shaft, induced a change of belief in this respect, the evidence there presented going to show that the beds derived their supply of copper from the lodes by percolation into the contiguous slates, and subsequent operations appear to have confirmed this view.

The most important probably of the different lodes struck in the several shafts is that known as the "Fanny Eliza." This entered the

Character of
the ore
deposits.

Nature of
the lodes.

bed near the intersection of the Kent shaft, and on this lode the greatest amount of work appears to have been expended. Where first struck, near the shaft, it was of small size, but rapidly widened as it was opened. Mr. Douglas says of it: 'The lode is from twenty to twenty-four inches in width, and very regular, both in dip and strike, which is slightly to the west. The ore, as it comes to the surface, yields from eight to twelve per cent copper. It separates in crushing, very perfectly from the gangue, and is therefore easily concentrated to from forty to fifty per cent. It consists of a mixture of gray and purple sulphurets. When the lode enters the bed it carries a good deal of yellow and no gray ore, but the yellow entirely disappears in depth. The ore occupies the centre of the lode, whose matrix consists of calcspar, some quartz and a good deal of bitter spar, in the composition of which iron replaces part of the magnesia.'

"Tracing the lode upward, but beneath the bed and beyond the spot where it first attracted attention, it is seen, in the thirty feet cross-cut, as a well defined lode of about eight inches wide, but carrying very little copper, and has been reached by a level driven upon it from the bottom of Kent's shaft, where, however, it is thin and irregular, though highly charged with copper.' From Mr. Douglas's paper we learn, further, that to the east of the Fanny Eliza two lodes enter the bed, on one of which, some work was done. The lode runs parallel with the Fanny Eliza, and like it increases in size in the direction of the dip, but diminishes towards the rise.' He says, also, that 'the beds gradually decrease in richness in proportion to their distance from the lode.' Mr. Douglas also maintains that the Fanny Eliza is a true lode maintaining its width and direction for forty fathoms with a regular dip, and holds that the veins which take their rise in the roof of the bed are also lodes and not lenticular masses. The vicinity of the lodes is indicated by an increase in the richness of the slates and the kind of ore which they carry. These mines, after having been idle for some years, have lately changed hands and are now being worked by the Excelsior Copper Co. From the notes of Mr. C. W. Willimott, who visited the spot in 1882, we learn that the mine closed work in 1879; operations having been confined principally to the Fanny Eliza lode or vein; in the level and incline which had been sunk to a distance of 600 feet, some rich pockets of ore had been found. The mines, in 1882, were owned by a New York company, but no work, other than taking the water out of the shaft, was then going on. The Excelsior Copper Co. had been carrying on work during the preceding two years, but had not extended their underground operations to any great distance, having merely cleared the shafts of water, repaired the timbering and the build-

ings and erected a smelter, in which a considerable quantity of the ore lying about had been reduced, the coke for this purpose having been obtained from Nova Scotia, the limestone from Dudswell, and the iron from McVeity's mine near Kinnears Mills, but no returns of output or of other results are to hand. The manager was Col. Drew Gay. This property again changed hands, and is now owned by Dr. James Reed, by whom some development work was done, though operations have been suspended for several years. The surface plant is now much out of repair.

On lot sixteen, range fourteen, adjoining the Harvey Hill property to the north, the Leeds Mining Co., began operations in 1863. These were carried on for a couple of years, in anticipation of meeting the extension of the rich lodes and beds of the Harvey Hill mine, but in this their expectations were not realized, since the extension of these beds to this property was not found sufficiently rich in copper to pay for mining. These works were suspended in 1865. They were under the general supervision of Mr. Herbert Williams, and no attempt has since been made to further develop the property.

The second range of mines in what was, in 1863, regarded as the eastern portion of the second synclinal, or that area east of the Sutton Mountain ridge, included those of Potton, Durham, Brome, Bolton, Oxford and Brompton. The rocks here, in places, differ markedly from those of the area just described, being very frequently black and variously colored slates, with great areas of serpentines and diorites, but the characters of the ore are, in some cases, similar to those from the west side of the Sutton ridge, though in certain of the mines, some features which are different will be mentioned. Ores of the second belt.

In the township of Potton, the yellow sulphide is the most abundant ore, the vitreous being rarely found. The rocks here are mostly slates and diorites with serpentines; the copper pyrites is largely mixed with iron pyrite, much of which is the magnetic variety or pyrrhotite. In no case yet observed in this township is the quantity of ore sufficient to warrant any great outlay in exploration, except, possibly, at the recently discovered mine on lot twenty-eight, range nine, on the west side of the Hogs Back mountain, owned by the Memphremagog Mining Co. This mountain is a mass of diorite, rising to a height of about 800 feet above Lake Memphremagog, and surrounded on both sides by black and bluish gray slates. The deposit of ore, which is principally a pyrrhotite with a small quantity of copper pyrites, occurs on the west side, at the contact of the diorite and slates, in a bed fifteen to eighteen feet thick, which extends Potton.
Lake Mem-
phremagog.

along the side of the mountain for several hundred yards. It dips north-west at an angle of about forty degrees, having the diorite for its foot wall, while the surface above the vein and for some distance beyond is covered with a heavy bed of bog iron ore. The copper ore, in situ, contains a considerable quantity of a dark-coloured or almost black calcite. On this vein several pits have been sunk at intervals along a distance of 1,000 feet, and, according to the manager, an inclined shaft has been put down on the vein for eighty-five feet. A cross-cut has also been driven with the vein, so as to drain the pits. About 800 tons of the ore have been extracted and piled, waiting for shipment. From several assays by Dr. Wyatt of New York, and by Torrey and Eton, the ore contains from different samples :—

Iron	30 to 50 per cent.
Copper.....	2·80 to 5 "
Sulphur.....	37·25 to 42 "

A peculiarity of this ore is the readiness with which it spontaneously ignites when piled in heaps exposed to the weather; a feature not common to the ores from most of the other locations.

This mine is situated at 700 feet above the lake, connected by a good road a mile in length with landing-stage, and good facilities for shipment, either to Magog or Newport. Recent developments on this property are mentioned on a subsequent page.

Bolton.

Huntington
Mine.

In Bolton, the township adjoining to the north, the extension of the slates and serpentines is found, and mining operations were carried on quite extensively for some years at several points within it. Probably the most important of these was the celebrated Huntington mine, on lot eight, range eight, and the Ives mine, a couple of miles further to the north, on lot two, range nine, and lot four, range eight. In the former, the ores are mostly copper pyrites, mixed with the magnetic pyrites or pyrrhotite, a large deposit of which occurs in chloritic slates in contact with serpentine and diorites. A band of more than three feet of solid granular copper ore occurs near the serpentines on the west side of the vein. A section of the metalliferous portion, going eastward from the western wall of serpentine is as follows :—

	Feet.
* 1. Greenish diorites, with disseminated masses of copper pyrites and magnetic iron pyrites.....	2·0
2. Compact granular copper and iron pyrites with disseminated masses of quartz	1·4
3. Magnetic iron pyrites, interstratified with thin leaves of chloritic and mica schist.....	0·9
4. Greenish diorite with disseminated copper and iron pyrites..	1·0
5. Compact granular iron pyrites, with disseminated small masses of quartz.....	2·6
6. Green chloritic slate, with disseminated masses of copper pyrites, mingled with iron pyrites....	8·0
	<hr/> 15·7

* Geol. Surv. Rep. 1866, p. 35.

Work was begun on this property in August, 1865. From notes kindly furnished me by Capt. W. Warne, the present manager of the Memphremagog Mining Co's. work, the management was in the hands of Capt. Bennett of Lennoxville, who controlled operations till 1870-71, when the mine was sold to a Glasgow company and the name changed to the Huntington Copper and Sulphur Co., under the management of Mr. John Rudda, of Cornwall. The output under the old company's management is stated to have been from 200 to 300 tons of ten per cent ore per month, part of which was shipped to England and part to the United States. Extensive buildings, etc., were erected, and under Capt. Rudda's management, the output was increased to 400 to 500 tons per month of seven per cent ore.

In 1872, works were erected for carrying on the Longmaid or Henderson process, which, however, did not apparently meet with much success. The ore was burnt in retorts to drive off the sulphur, then crushed, mixed with common salt, and calcined in furnaces, placed in vats with hot water and acid from the tower, and run off into other vats containing scrap iron, by which the copper was precipitated. Hundreds of tons of precipitate, containing 65 to 75 per cent of copper, are said to have been made in this way.

In 1873, the works were destroyed by fire with a loss of \$75,000. They were partially rebuilt, and mining was carried on in a desultory fashion for several years, and the company finally closed operations in 1883. In 1888 the property passed into the hands of Messrs. G. H. Nichols & Co., of Capelton.

In the working of this mine, two deep shafts were sunk, one to the depth of between 500 and 600 feet, called the Huntington shaft, the other known as the Wright shaft, 200 feet deep. North of the Huntington mine, on lot six, range eight, were the works of the Canadian mine, presumably on an extension of the vein just described. Two shafts were here sunk, one to a depth of 100 feet, the other to 50 feet, and some ore shipped to Capelton. The mine subsequently passed into the hands of the Eastern Townships Bank and has not been worked for some years.

Further north, on lot two, range nine, Bolton, the Ives mine was situated. Two shafts were here sunk, the Ferrier and the Galt, the former to a depth of about sixty feet, the latter to 100 feet. This mine was opened in 1866, and worked for ten years, and a large quantity of from 10 to 14 per cent ore was extracted and shipped to Bolton, Ives mine.

England. These three mines are situated on the east side of the Missisquoi river, south of what is now known as Eastman, and are all probably located on the same belt of ore. The serpentine rock is found at all these mines, with slates of various colors, differing, in this respect, from the rocks of the second area or that west of the Sutton mountain. Very favourable reports on these deposits have appeared by Dr. T. Sterry Hunt and others, but the presence of the magnetic pyrites serves to distinguish the ores as a class from those already described.

Orford.

The copper deposits of Orford township were mined at several points. On lot nine, range A, yellow sulphide occurs in a dioritic rock, near serpentine, of which six veins are found in twenty-five feet. This was exploited by Messrs. McLeod and others. On the third lot of range F, and on the eighth lot of the same range, similar ores, with a like association of rock matter, were found, but at none of these does systematic mining seem to have been carried on.

Brompton
lake.

At the King mine, on the third lot, in range thirteen, variegated ore, associated with magnetic oxide of iron, occurs in a four-foot band of dolomite and serpentine; and on the west side of Brompton lake, on the east side of a high hill, called the Carbuncle, composed of diorite and serpentine, several small openings were made, from which, in all, about twelve tons of twelve per cent ore are said to have been obtained. The difficulties of working this deposit, from its comparative inaccessibility, must have been very great, and the quantity of ore in the rock appears at present very limited, although a five feet vein of solid yellow sulphide is reported to occur there. This mine was styled the Carbuncle Hill mine and was located in the second lot of the fourteenth range of Orford. In the township of Brompton, the only mine worked was on lots twenty-eight and twenty-nine of range nine, where the ores, which were of the variegated and vitreous varieties, were found in serpentine. According to Mr. Chas. Robb, the principal deposit was in a five feet vein, containing, according to his report, a promising quantity of ore. It has, however, long since been abandoned.

Mines of the
third area

In what we have styled the third area, viz., that of Ascot and Hatley, we find a great series of deposits which have of late years proved to be among the most valuable in eastern Quebec, not probably so much for the amount of copper contained as for their adaptability to the manufacture of sulphuric acid. In this respect the ores of this most easterly belt differ widely from those of the two areas already described.

Ascot and
Hatley.

The variegated and vitreous ores are, for the most part, wanting, the bulk of the ore being a chalcopyrite, with much iron pyrites. The amount of copper contained is not high, averaging, for the great bulk of the production, from four to five per cent., while in most of the ore there is an appreciable quantity of silver, reaching, in some portions, as much as twenty-five to forty dollars per ton of ore, but yielding, on the average, from four to five dollars. A certain amount of gold is also present, but, as no attempts have yet been made to save this, the quantity is unknown. Silver and gold.

These mines are situated in what we now regard as the Sherbrooke and Stoke mountain anticlinal, and the rocks are chloritic, micaceous and talcose schists, with diorites. On this belt of rocks, southwest of Sherbrooke, and extending to the north line of Hatley, a large number of mines have been located, some of which have been worked for many years, while others, although containing valuable bodies of ore, have been idle for some time. In the township of Hatley the deposits appear to be much less numerous; the belt of schists becomes narrower, probably in part owing to the overlap of the black slates of the Cambrian system. The most southerly deposit of copper ore in this direction is near the upper end of Massawippi lake, on the west side, on lot nine, range six. At this place there appear to be two kinds of rock, the soft blackish and bluish pyritous slates being in contact with the hard quartzo-felspathic rocks of the mountain series. The contact is probably along a line of fault, and the ore, which is scattered through a width of eight to ten feet, is in the form of the yellow sulphide, but the shaft being filled with water, the quantity could not be ascertained; a large amount of iron pyrite appears to be mixed with the copper ore. This is the Parnell mine. The only other mine located in this township is that on lot twenty-eight, range one, known as the Reid Hill mine. It has an elevation of 500 to 600 feet above the Massawippi river, and presents the appearance of six beds of the yellow sulphide, with iron pyrite, in a space of a fourth of a mile in breadth. Similar ores appear on the lots to the west, on ranges two, three and four adjoining. Considerable exploratory work was done at this place, and a level was driven in about 200 feet below the outcrop of the bed, but no details of the workings or subsequent exploration are at hand. Mines south of Sherbrooke.

Beginning with this mine and passing into Ascot, there appears to have been an unusual development of this variety of ore, more particularly in that portion to the south-west of the St. Francis river, though large and very valuable deposits have also been discovered in the extension, to the north-east, of this anticlinal. The ores are

apparently all yellow sulphides, and no less than fifty-five localities were at one time reported as copper-producing or giving good indications of the ore. In all, up to 1865, thirteen mines were operated, of which the localities may, for the sake of reference, be briefly noted as follows, but since that date several others have been opened :—

The Clark mine—Lot eleven, range seven.

The Sherbrooke mine— Lot twelve, range seven.

The Albert mine—Lot three, range eight.

The Eldorado or Capel mine— S.E. $\frac{1}{4}$ lot four, range eight.

The Victoria mine—N.E. $\frac{1}{4}$ lot four, range eight.

The Ascot mine—W. $\frac{1}{2}$ lot eight, range eight.

The Parks mine—W. $\frac{1}{2}$ lot twelve range eight.

The Short mine—Lot fourteen, range eight.

The Lower Canada mine—Lot three range nine.

The Marrington mine—N.E. $\frac{1}{4}$ lot six, range nine.

The Hill mine—E. $\frac{1}{2}$ lot eight, range nine.

The Belvidere mine—Lot ten, range nine.

The Magog mine—Lot eleven, range nine.

The Griffith mine—Lot three, range eleven.

These are the mines mentioned in the report for 1866, and in addition, several other areas, not distinguished by any particular names, occur, on which a greater or less amount of development work has taken place. Several mines have also since been opened, which promise well in view of the present large demand for sulphur ores. Among these may be mentioned the Suffield mine, on lot three, range eleven; the Cillis, now the 'Howard,' on lot five, range eleven; the Hepburn mine, on lot seven, range nine; and the Moulton Hill mine, north of the St. Francis river, on lots twenty-three and four, range three. The width of the ore-bodies, or lenses, in this section is very great, in places being considerably over fifty feet, and the breadth of the ore-bearing rocks, south of Sherbrooke, is about three miles, while from the Parnell mine, on the south, to the Moulton Hill mine, on the north, the distance is about twenty miles. Still further to the north, again, in Garthby, large deposits of similar ore have been reported.

The first reference to the copper ores of this section is found in the report of the Geol. Survey for 1847, where an outcrop of a vein in the

Large ore
bodies.

fifteenth lot of the seventh range, is mentioned as worthy of trial, which was found to contain, in addition to copper, small quantities of silver ^{Silver.} and gold ; the latter, however, not in quantity to be of economic importance, but of interest as showing the possible presence of the precious metal in greater quantity in other veins of the vicinity. On the thirteenth lot of the same range, the continuation of this deposit carried copper pyrites in veins, distributed throughout a belt of thirty feet of chloritic slates. This lode, on lot fifteen, was at the time traced for a distance of about fifty yards, but from half to one-third of a mile, further to the south, could not be found. When first opened, it had a breadth of from ten to twelve inches. Up to 1858 no further interest appears to have been taken in these deposits, only two places being referred to in the report for that year, viz., that just mentioned and lot nineteen, same range, where a small vein of copper pyrites was seen in a railway cutting near Sherbrooke station on the Grand Trunk railway. In 1859 the Ascot mine was discovered by Thos. McCaw, of Montreal, at Haskill hill, and found upon examination to consist of a bed of copper pyrites mixed with iron pyrites, having a thickness of five to six feet, in a matrix composed of impure limestone and chloritic schist. This mine was, in the fall of 1863, purchased by an American company, who erected furnaces for smelting the copper ore at Lennoxville. In the Geology of Canada, 1863, reference is made to but three mines in this vicinity, viz.: the Ascot, Haskell Hill, the Belvidere and that first discovered and already described. The ore was similar throughout, and the breadth in the Belvidere lode was estimated at six feet. What was afterwards the Marrington mine on lot six of the ninth range, showed a vein of from two to three feet at the surface, with a large proportion of iron pyrites. During the next two years a very extensive development in mining took place ; a large number of mines were opened and a very considerable quantity of ore extrated.

From notes kindly furnished me by Mr. T. Macfarlane and by J. S. Hunter, now of Belleville, I am able to give a few notes in regard to some of these, not already made public.

The Clark mine is situated one mile and a half from the Lennoxville station, G.T.R., on lot eleven, range seven, Ascot. This was first opened in 1863, by Mr. Wm. Clarke, and was worked with more or less vigour for several years, principally by an American company, who took out a large quantity of ore. The work was carried on for the most part by means of open cuttings upon a vein said to have a thickness of eighteen feet, (?) and containing three and a half per cent ^{The Clark mine.}

of metallic copper. This estimated thickness of the ore bed is, however, doubtless exaggerated, since, on the most reliable authority, the thickness never exceeded seven to eight feet, and gradually decreased to eighteen inches. In addition to surface workings, a pit was sunk to a depth of forty feet and a shaft to seventy-three feet. Further explorations were carried on in 1866, but without success, and in that year the mine was sold at sheriff's sale. No returns as to quantity or quality of output are at hand, and the mine has apparently remained idle since the date mentioned.

The Sher-
brooke mine.

The Sherbrooke mine immediately adjoins that just described, to the south, and is traversed by the same lodes as are found in the Clark mine. It has been quite extensively explored on the surface, though not yet opened up by underground exploration. Several valuable deposits of pyrites are reported on this property, one of which is said to have a thickness of eight feet, while another was stated to be no less than seventy feet in width. (?) Assays by several persons give from \$4.00 to \$5.00 of gold, \$11.00 per ton of silver, and from 30 to 40 per cent of sulphur.

A group of three mines, situated on lots three and four, range eight, and lot three, range nine, are worthy of special notice, not only from their early history, but from their great and growing importance at the present time. These comprise what were formerly known as the Lower Canada, or Hartford, now the Eustis or Crown mine, the Capel or Eldorado, and the Albert; the last named being now owned by the firm of G. H. Nichols & Co.

The Capel
mine.

The Capel mine was so called from the name of the original owner of the property, Mr. Geo. Capel, and in 1863, chiefly through the agency of Mr. W. S. Hunter, three men, Mr. Hunter, Mr. Carlos Pierce and Mr. Capel, formed a company to develop the property on lots three and four of range eight. These gentlemen spent from eight to ten thousand dollars in exploratory work, and, finding the results satisfactory, divided the property into two portions; the eastern area, on range nine, being styled the Prince Albert mine. The property was soon acquired by Montreal capitalists, by whom mining operations were commenced, and have been carried on to the present day, though under changed ownership and management.

From the Montreal firm the property passed into the hands of Taylor and Sons of London, who adopted the Henderson process for the extraction of the metallic copper. This, however, after a thorough trial, failed to give satisfaction, and the mine was closed. The property subsequently changed hands, and was finally purchased by

Messrs. G. H. Nichols & Co., an American firm of ability, by whom the ores have, for the most part, being shipped to the sulphur works at New York or vicinity, for the manufacture of acid. Within the last three years, however, a somewhat extensive plant has been erected at the mine for the manufacture of sulphuric acid on the spot, as well as for that of superphosphate. Smelting works have also been still more recently started for the production of matte. The success of the present company is no doubt largely due to the saving of the sulphur and other by-products of the ore, in which the profit consists. The depreciation of the copper market at the time of the former management, combined with the loss of the sulphur, was such, that expenses apparently could not be met. The deposits at the Albert and Capel mines are doubtless a continuation of that found to the south-west at the Crown mine, formerly the Lower Canada. There the ore bed is an immense, but somewhat irregular deposit of chalcopyrite, mingled with much iron pyrites, yielding an average of four to five per cent. of copper, some of the ore being very rich, and in addition containing an appreciable amount of silver. The lode varies in width from four to Silver. over fifty feet, and has been worked to a depth of over 1,600 feet. At the Eustis or Crown mine also, smelting works have been erected, in which a large amount of matte is made, the sulphur in this case being wasted, but a very large proportion of the ore still goes in the raw state to the sulphuric acid works in the vicinity of New York, while the residue is treated for copper at the smelting works at Bergenport, New Jersey. The owners of the latter are the Eustis Mining Co. The ore at this mine apparently occurs conformably with the bedding; the irregularities in size being due to local thickening of the ore mass. Dykes of diorite are met with in the different under-ground workings, and can also be seen at the surface in the immediate vicinity of the mines. The rocks containing the lode are schists, often highly micaceous and talcose, but generally chloritic, which are traversed by numerous quartz veins. The ore is delivered on the railway, about half a mile distant from the Albert mine, by an elevated cable tramway, carrying the ore buckets, and from the Eustis property by a gravity tramway to the track, where it is dumped directly into the cars. From several assays of this ore the quantity of sulphur is found to vary somewhat, but averages 38 to 40 per cent:—

Iron.....	35
Copper.....	4 to 5
Silver, about one ounce per unit of copper, say 4 ounces per ton.	

The Lower Canada mine, or the Crown mine, now so called, was discovered in 1865. For two or three years thereafter it was worked for copper alone, but subsequently for copper and sulphur. This mine is well described in the Geological Survey Report for 1866, from which the following abbreviated extract may be made as illustrating the character of the workings and of the ore at that date.

Character of
the ore bodies.

The strata for a distance of 1,600 feet dip S. 30° - 40° E. $< 40^{\circ}$ - 60° , and in this distance five shafts have been sunk in micaceous schist, to the south-east of a dolomite band, and to all appearances in the same bed of ore. In shaft No. 1, the ore is ten feet thick, the lower four feet of which is apparently an almost compact mass of the yellow sulphide of iron and copper. Upon this are two feet of similar character, but yielding only about five per cent of copper, and the upper four feet contain iron pyrites alone. No. 2 shaft 125 feet south-west of this, is sixty feet deep, and the ore bed is four feet and a half thick; the lowest part is similar to that in the first shaft, but is said to yield fifteen per cent. copper, while the remainder yields only three per cent. The ore bed, as shown in shafts Nos. 3 and 4, sunk to a depth of 75 and 132 feet respectively, is similar to that in No. 2, but in No. 5, sunk 90 feet, the bed is six feet and a half thick and vertical for eighty feet from the surface, thence dipping S. 40° E. $< 40^{\circ}$ - 50° . In the vertical part it contains only iron pyrites but below this sufficient copper pyrites becomes mixed with it to cause the bed to yield between three and four per cent. of metallic copper. Other bands of copper ore occur in this lot, on both sides of shaft No. 1.

Subsequently to the date of the above report, mining operations were vigorously carried on, and in addition to the copper, which was originally the sole object of the enterprise, the large amount of sulphur contained in the ore was utilized for the manufacture of sulphuric acid, both in Canada and the United States. Up to June, 1869, about 20,000 tons were smelted to 40 per cent. regulus on the spot. A very large quantity was shipped to acid works, the amount of sulphuric acid obtained being stated at one ton of 66° acid to each ton of ore.

The yield of ore from these mines at present is very large and apparently annually increasing. The output for 1889, taken from the returns of the Mining Review, was, from the Eustis mine, 34,089 tons, including 1,773 tons matte, and from G. H. Nichols & Co. 36,000 tons.

As regards some of the mines alluded to in the list given in a preceding page, but little can here be said. A considerable amount of exploratory work was done on some of these and the promise of fair sized ore beds seemed good, but, in most cases, this work was not

pushed to a sufficient depth to decide as to the actual value of the property. That this appears to be true can be seen by reference to the great mines of Capelton and by a comparison of the enormous size of the lode in the lower levels, with its rather limited extent at the surface. Among others, not noticed in the list of 1866, may be mentioned the Suffield mine, on lot two, range eleven; the Hepburn mine, on lot seven range nine, where a large amount of exploratory work appears to have been done; and the Cillis mine, on lot five, range eleven, which has, within the last year, been reopened to a greater depth, and the ore has been found to increase in quantity and quality so greatly that it is now considered an exceedingly valuable property. It has been purchased by an American syndicate and will be worked.

From notes obtained by Mr. Willimott in 1882* the Hepburn ^{Hepburn mine.} mine was then being worked quite extensively. Like the Ascot and Suffield mines, it was the property of the Sherbrooke Mining and Smelting Co. A shaft was sunk to a depth of 156 feet, and at sixty feet a level had been driven for thirty feet, from which a north and south cross cut was made. The latter was carried 110 feet, at which distance a bed of yellow sulphide twenty-four feet thick was cut, averaging about seven per cent. metallic copper. The north cross cut was carried ten feet, where another bed of yellow ore was cut, said to be twenty-seven feet thick. No ore has been raised, the object of the company being to develop a large reserve.

About twenty men were employed at the mine. Work at this property was shortly afterwards abandoned. The quality of the ore in the dump, seen in 1885, looked well. Of the Suffield mine, Mr. Willimott says: 'A shaft has been sunk 200 feet; at the depths of eighty-five feet, and two hundred feet, levels have been driven to the east, the former 300 feet and the latter 100 feet, connected by a ventilating winze.'

The amount of exposed ore is reported at about 40,000 tons, of which 3,500 to 4,000 tons have been taken out with the intention of concentrating and smelting at the mine.

At this mine the drilling was done by compressed air, driven by an engine of sixty horse power.

The ore resembled that from the Capelton and Hartford mine, an assay of which was made by Dr. Harrington in 1877, yielding 75·03 ^{Silver.} ounces of silver to the ton. Assays of the Suffield ore, by John Massey & Co., London, England, gave percentages of silver, varying from eight ounces to 235 ounces per ton and from four to twenty-nine per cent of metallic copper.

* See Geol. Surv. Rep. 1882-3-4

Areas north
of St. Francis
river.

In the area north of the St. Francis, deposits of ore occur precisely similar to that of Capelton, and in similar rocks. What has proved to be a very valuable deposit was found about three years ago by Mr. Burke, the owner of the land, on lots twenty-three and twenty-four of the third range of Ascot, which has since been somewhat extensively developed, and purchased by the same syndicate which acquired the Cillis mine. The bed of ore which dips with the slate south-easterly at an angle of 45° - 50° was found to rapidly increase from the surface showing of four to six feet to a reported thickness of not far from fifty feet, at a depth of seventy feet, revealing an enormous body of ore. This location was revealed by the uprooting of a tree, and is in the direct course of the Capelton deposit, which it so much resembles.

In view of the fact that these several ore beds, which are found over a breadth of some three to four miles, resemble each other very closely, and from the crumpled and overturned character of much of the strata in which they are contained, it seems most reasonable to suppose that the greater part of these mines were located upon different portions of the same lode, repeated by folding from place to place, and that as large and valuable deposits of the ore have been found at widely separated portions of the same vein, both in the southern and northern portions of the township, and almost equally valuable deposits are known in the more western portion of the belt, as at the Cillis mine, it may be very safely predicted that the real value of many of the mines which were opened twenty-five years ago and speedily closed, has never been ascertained, and that other masses of ore, of equal importance to those so long worked, will, by careful prospecting, be found at no distant date. Much of the failure of twenty-five years ago was, doubtless, due to the speculative character of the work done. Mines were bought and sold on the flimsiest sort of evidence as to their value or worthlessness; often on samples which were obtained from an entirely different location from that represented. The growing importance of these ores as a source of sulphur for sulphuric acid is being very fully realized by the men interested in this industry in the United States; their superiority over most of the United States ores, for this purpose, being acknowledged. There are yet, in this eastern belt, many places thickly covered by forest growth, the prospecting of which is a difficult matter, but of the many mines already opened and abandoned, it is highly probable, as in the case of those now worked, that deeper and more scientific testing would change the aspect of things greatly for the better.

Further to the north, in Garthby, a considerable deposit of pyrites is found on lot twenty-two of range one. This deposit is described in

the Geology of Can. 1863, p. 733, as 'a large mass of iron and copper pyrites, subordinate to the stratification of the enclosing rock which is a calcareous serpentine, dipping to the south-east at an angle of 50°. The extent of the deposit has not been determined, but there appears to be a breadth of about twenty feet, in which the two ores are more or less mingled with rock. Large masses of the mineral consist of a fine-grained iron pyrites, without any copper, while in other portions the ore is such an admixture of copper pyrites as to afford eight per cent. of the metal.'

The ore at this place occurs in rocks differing in age from those of the area just described, being more closely allied to the deposits of Bolton and Potton. The first opening was made by Mr. J. B. Coulombe, in 1860, and was nine feet long, five feet wide, and said to be sixty feet deep. No work was done on the property after 1861. An analysis of the iron pyrites apparently free from copper gave iron 42, sulphur 48, copper 1.1, silica 8.9 per cent.

This property is about four miles from the Quebec Central railway, and recent explorations, during the past year, in the southern part of the area, are said to have developed a large body of ore, the associated rocks being traced into South Ham for a distance of three miles, but no definite information can be obtained on this point.

In the townships of Ham and South Ham, several mines were also at one time started, but these, apparently from an insufficiency of ore, have long since been closed. Among these may be mentioned the Nicolet Branch mines on lot twenty-eight, range four, where the variegated and vitreous ores were found scattered through a band of dolomite and chloritic schists, overlaid by glossy black slates. The ore is found in small veins only, disseminated through the rock, and by exploration over several hundred feet, several tons of rich ore were obtained. On range B, lots thirty-three to thirty-six, explorations were made on the right bank of the Nicolet river, on similar ores in green rocks, like the last, but without success, only small quantities apparently being found. 'In South Ham, in the serpentine and diorite rock of the south and east side of Nicolet lake, small deposits, mostly of the yellow sulphuret, occur on lot twenty-two, range one, old numbering, or lot forty-four, range one, new numbering. This was styled the Nicolet Copper mine. A small amount of exploratory work was also done on lot fifty-two, range two, new numbering, but no returns are at hand.'

Further north, in the township of Thetford, copper ore has lately been reported by Dr. Jas. Reed, as occurring on lots three, four, five

and six of the first range, and on lot fifteen of the second range of Leeds, as well as lot nineteen of the second range of Thetford, but the quantity and character of the ore are unknown, the locality not having yet been explored.

The more recent developments in connection with the copper ores of the province are taken from the reports of Mr. J. A. Dresser to this department, who devoted several season's work to their study over a large area; and from reports by Mr. J. Obalski, inspector of mines for the province.

Recent work
by Prof.
Dresser.

In his report for 1902, Mr. Dresser expresses the opinion that in the area of Cambrian rocks the copper occurs only in, or in close association with, igneous rocks of the district, all highly metamorphosed; that the ore does not occur as true veins, but in rudely lenticular masses, and that many of the rocks, formerly regarded as altered sediments in this association, are really altered volcanics.

In 1903, this view is somewhat elaborated and he says, 'the ore bodies have not been observed to form true veins in any case. In numerous cases they show in surface exposures, the elliptical outlines of much flattened lenses conforming to the foliation of the rock. The walls are not well defined and "horses" and lean ore masses are not infrequent within the larger ore bodies. The largest ore bodies were seen in the Eustis mine, where masses occur which are more than 100 feet in the least dimension, while they generally follow the dip and strike of the foliation which affords a useful means of tracing ore bodies; at times they also cross the plane of schistosity of the country rock at an oblique angle. Then they have more nearly the character of true veins. Such bodies appear to cut the dip more frequently than the strike of the enclosing rock. The lenticular bodies also appear to be frequently arranged in echelon, since the lode, when lost, is most frequently recovered, not by following through the pinched out part along the strike, but by driving at right angles to it.'

Among new properties developed in recent years may be mentioned the following:

Melbourne.

Lot 7, range 1, Melbourne, by Mr. W. F. E. Bowes of Chicago, who opened up a deposit of copper pyrites and bornite in stringers in quartz, by a shaft seven feet and a half square, to a vertical depth of 50 feet, the copper-bearing portion being about a fourth of the width. The copper pyrites was said to yield 24 per cent. of copper and 32 per cent. of sulphur; the bornite 19 per cent. of copper and the same of sulphur with gold reported at \$9 per ton.

Several of the old mines have been reopened to some extent, including the Ely, the Balrath of Melbourne, and certain areas in Leeds, Shipton, Brome and Chester.

On lots 17 and 18, range III, of Weedon, iron and copper pyrite is found in veins, masses and grains in the country rock but the property is not yet developed.

The new belt of copper-bearing rocks which has been indicated by Mr. Dresser as occurring adjacent to the Maine boundary in the Megantic district, shows the presence of large areas of volcanics. Copper and iron pyrites were found on the line of the Canadian Pacific railway at the 189th mile post from Montreal, exposed in a cutting through a belt of rusty rock of twenty rods in extent. The central part of the cutting shows the pyritous ores in a belt about ten yards in width, but as the cutting is oblique to this strike the actual width of this is somewhat less. The country in the direction is as yet largely wooded and unopened, but Mr. Dresser thinks from the nature of these rocks that other deposits of copper ores will be found. This belt is probably in the line of that opened up in the townships of Risborough and Marlow on lots 1, 2 3, ranges XIV, XV and XVI of the latter, and described in the Report by the writer for 1888-89, as carrying galena, pyrite and blende ores, with which also the somewhat rare mineral scheelite is found in considerable quantity, as ascertained by Mr. W. F. Ferrier, some years ago. At that time similar ores were reported as being found in the township of Spaulding and at several points in Ditton and Emberton, which are all within this fourth copper belt of the Eastern townships.

The Eastern belt or Megantic area.

Scheelite.

The Smith mine at Hogs Back mountain, near Knowlton landing, has, since the report for 1888-89, been further developed by sinking a shaft about 80 feet deep, and by a horizontal tunnel one hundred feet in length cross-cutting the ore body in the shaft at 50 feet from the surface. The ore carries from 1 to 7 per cent of copper with about 35 per cent of sulphur and a small percentage of nickel, and is a pyrrhotite. A considerable body of bog ore forms a capping over the main ore body and this has been shipped to the furnaces at Drummondville for the manufacture of iron. There appears to be a very large body of the pyrrhotite at this place, but beyond development work to a limited extent, but little mining has recently been done. It occurs along the contact of the diorites of the Hogs Back and Sugar Loaf mountains with the belt of black slates which traverses this district.

Smith mine lake Memphremagog.

Nickel.

A similar occurrence of conditions with a smaller ore body is reported on John Burbank's farm, about three-fourths of a mile north of the Smith mine, the mineral zone being from a few inches to two feet in width.

Ascot mine.

In Mr. Obalski's report for 1901, work is said to have been resumed on the Ascot mine, by Mr. Wilfrid Johnston of New York. The ore is chalcopryite and the ore body has been opened by a shaft for 250 feet on a slope or to a vertical depth of about 170 feet. The ores are irregularly disseminated through quartz schist, in varying proportions, in a vein 7 feet wide with a solid part in places of two feet in width.

At the King mine on west half lot 4, range XI, Ascot, a deposit of iron pyrites, carrying small quantities of chalcopryite and various sulphurets, with a variable proportion of gold and silver, was opened in 1898-99. Several shafts were sunk, one, the Silver Star, on an incline of 35 degrees from the vertical to a depth of 40 feet, showing veins of 7 to 8 feet, of which 2 to 3 feet were well mineralized; and the Norton shaft, also on an incline for 100 feet, and connecting with the old Howard mine on lot 5 which was worked several years ago by an American company through Mr. F. J. Falding. Several hundred feet of drifts have been opened on the ore body and a considerable quantity of ore extracted which yielded on an average, from $2\frac{1}{2}$ to 3 per cent of copper, 5 to 7 ounces of silver and from 31 to 33 per cent of sulphur.

The Balrath mine was also recently opened from the 620 feet level in order to obtain samples but otherwise no mining has apparently been attempted. A deposit of chalcopryite has also been opened to some extent, in diorite, on lot 15, range VIII, Thetford. Some development work at the old Harvey Hill mine, now owned by Dr. James Reed, has also been done, but no systematic mining has been attempted for some years.

Matane.

Copper was found three years ago about 12 miles east of the village of Matane and 6 miles south of the river St. Lawrence. Some small pieces of native copper were found in an eruptive mass of diorite, while chalcopryite and bornite occur in light-gray calcite in black slates of the Sillery formation, two or three hundred yards south of the diorite. Some development work has been done by shafting and boring. This deposit belongs to those of the first division of the copper belts instead of to the pre-Cambrian rocks, and resembles several of those described as occurring south of the St. Lawrence in the Sillery slates and sand-

stones to the south-east of Levis, where the same diorites come to the surface and shew similar ores near the contact. The company owning the property at Matane is styled the Matane Gold-Copper Mining Co.

In addition to the localities for copper already described as occurring in the province of Quebec, several others are known to exist, concerning the actual value of which, but little is at present known. Among these may be mentioned Lakes Chebougamau and Obatogamau, lying some miles south-west of Lake Mistassini. In the report for 1870-71, pp. 293-295, Mr. James Richardson notes the occurrence of copper ores in this area, and describes the rocks as green chloritic slates, dolomites, masses of serpentine, conglomerates, etc. In a map recently issued by Dr. R. Bell, these rocks are regarded as of Huronian age and as forming a belt extending for nearly 100 miles in length, with a breadth of about eight miles, in a direction south-west from Mistassini lake. North of
Quebec.

Mr. Richardson says of these deposits: "Copper pyrites has already been mentioned as occurring in the neighbourhood of Paint mountain on Lake Abatogomow. At a point a little to the south-west of the mountain, on the lake shore, this ore is met with in specks, together with stains of the green carbonate, but no well-defined bed or vein was observed. The rock is a green, slightly calcareous, chloritic slate. These indications of copper are seen for nearly half a mile north-easterly along the lake shore to another point, where a bed or vein two feet thick, containing copper pyrites is seen in chloritic rock for about twenty feet. Its strike is N. 31° E. and S. 37° W., the underlie not being determinable. The portion of the vein exposed would probably yield four or five per cent. of copper throughout, while parts of it might produce ten or twelve per cent. For about three-quarters of a mile farther along the shore, specks of the yellow sulphide and the green carbonate of copper are met with wherever the rock appears. At the end of this distance, and just under Paint mountain, the rock is largely charged with fine-grained iron pyrites and specks of yellow sulphide, in a yellowish quartzose gangue. Here the iron pyrites constitutes as much as fifteen to twenty per cent. of the rock, while along the whole distance above described, about one mile and a quarter, it is never absent, though occurring in small quantities. At the last mentioned place is the depression described on page 293. As before stated, it is filled with drift, and no rock is seen on it; but from the quantities of iron and copper pyrites met with in the rock on both sides of it, it is quite possible that under the drift a valuable deposit of copper ore may exist."

Attention has been recently directed to these deposits and to other minerals which probably occur in the area, by the officials of the Crown Lands Department, Quebec. Copper pyrites was found in quartz veins cutting the Huronian rocks in two or three places on the Bell river or western branch of the Nottaway.

At Port Daniel also, on the south side of Gaspé peninsula, in a small vein of barytes, grains of copper pyrites and green carbonate of copper were observed and referred to in the *Geology of Canada*, 1863, page 771. Dr. R. Bell also in 1862, noted the presence of nodules of purple copper ore replacing plant stems in a soft arenaceous shale probably of Devonian or Lower Carboniferous age, in the same neighbourhood. This last occurrence is apparently similar in character to the deposits described in the Carboniferous of New Brunswick and Nova Scotia.

Output.

At present, and for some years, the copper production of Quebec has been derived from the pyrites deposits of the Capelton district. The annual production has varied considerably within the last 16 years, as can be seen from the figures issued by the Section of Mines of this Department, and lately has shewed a marked decline in the output, due to several causes, though the extent of the deposit as a whole appears to show but little diminution save that due to the usual variations of the ore body. The workings have now reached a great depth, but the breadth of the pyrites is in places of large dimensions. The figures given in the Report of the Mines Branch for the sixteen years prior to 1903 are here reproduced.

	Pounds.	Value.
1886	3,340,000	\$367,400
1887	2,937,900	330,514
1888	5,562,864	927,107
1889	5,315,000	730,813
1890	4,710,606	741,920
1891	5,401,704	695,469
1892	4,883,480	564,042
1893	4,468,352	480,348
1894	2,176,430	208,067
1895	2,242,462	241,288
1896	2,407,200	261,903
1897	2,474,970	279,424
1898	2,100,235	252,658
1899	1,632,560	287,494
1900	2,220,000	359,418
1901	1,527,442	246,178
1902	1,640,000	190,666